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THE UNIVERSITY OF ALBERTA

TAXONOMY AND ECOLOGY OF THE HELMINTHS OF THE AMERICAN COOT IN ALBERTA

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled Taxonomy and Ecology of the Helminths of the American Coot in Alberta submitted by Murray Hugh Colbo in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

In this study 371 American Coots (*Fulica americana*) examined from the area around Edmonton, Alberta, harbored 36 species of helminths, including 14 trematodes, 9 cestodes, 8 nematodes, 4 acanthocephala and 1 leech. There were 10 new host records and 2 new North American records.

The coot was a main host of 14 species (12 specific to the Rallidae), an auxiliary host of 4 species, an accidental host of 6 species and an inhibitory host of 12 species, including the most abundant form. Most of the species not specific to the Rallidae are found in a wide variety of water birds.

No correlation between the helminth fauna and the sex or condition of the host was found. Two of the common helminths were found only in adult coots; these appear to be "southern" species, whereas all the rest appear to be "ubiquists". The other common species were maintained primarily by infections in adults, four others by infections in immatures. The intensity of infection was generally higher in immatures than in adults. Most of the species of helminths of immature coots are acquired between the second and eighth week of life.

Changes in the environment between 1963 and 1964 were reflected by changes in the helminth fauna. Differences in the helminth fauna of coots from the three habitats sampled were also found.

Five patterns of seasonal fluctuations in the extensity of infection, with peaks in the spring, both spring and fall,

summer, fall, and irregular fluctuations, were found. Decreases in the helminth numbers in adult coots in June were correlated with the hatching season.

The diversity of the helminth fauna reflected the diversity of food eaten. Some of the differences in helminth infections with age, season and habitat appear to be mediated by food habits. Certain food items could be correlated with helminth infections; however, intermediate hosts of some common helminths were not found in the stomach contents.

Minor pathological reactions were common but no debilitating helminth infections were found.

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INTRODUCTION

The American coot, *Fulica americana* Gmelin, is a summer resident of Alberta. The main breeding population occupies the prairie and parkland areas, although coots breed as far north as the Peace River Delta. The major habitats in Alberta are sloughs and lakes having open water areas adjacent to emergent cattails, sedges, or rushes. The birds arrive in late April, commence nesting by early May and hatch their broods throughout June and early July. By the first of September the coots are collecting in flocks on larger bodies of water and by the end of September the majority of adults have migrated. The young remain until the larger lakes freeze up in early November. The Alberta coots apparently winter throughout the southern United States from California to the Atlantic coast (Ryder, 1963). A general report of the coots in Alberta was made by Smith (1956).

The present study was undertaken, in the spring of 1963, to survey the helminths of the American coot in Alberta with emphasis on the effects of various ecological factors on helminth populations and to determine whether an appreciable exchange of parasites occurs between coots and other water birds. Thus during the summers of 1963 and 1964 samples of coots were taken in each half-month period from selected areas near Edmonton, Alberta.

Specimens of all parasites found have been deposited in the collection of the Department of Zoology, University of Alberta, Edmonton, and/or that of the author.

MATERIALS AND METHODS

A total of 371 *Fulica americana* (230 adults, 141 immatures) were collected from April 15, 1963, to November 15, 1964. Data on the locality and date of collection of these birds are summarized in Table I. All coots were collected by the author except one collected at Cawes Lake, April 28, 1963, by Dr. O. Höhn. All birds were shot. They were placed in plastic bags and tagged with location and date. The birds were kept cool until they could be returned to laboratory and either autopsied within eight hours or immediately deep frozen.

The weights, linear measurements and colors were recorded as shown on the first page of the special autopsy sheet (Fig. 1). Next, the tarsal joints were examined for parasites. The joint required careful separation of the skin and tendons to locate the filarid, *Spirofilaria fulicaeatrae*. This was carried out properly only in 1964. The head was then removed and the mouth, nasal passages and eyes examined. The thoracic and abdominal cavities were then exposed. The air sacs, trachea and esophagus were examined; then the digestive tract was removed to a separate dish. The sex was noted and gonads measured and preserved. The lungs and kidneys were examined and the body discarded. The size of the Bursa of Fabricius and the lengths of the intestine and the caeca were noted before the remainder of the digestive tract was slit and examined. Further details of the examination of the various

Table I. Collection localities and dates of coots examined in this study.

			Apr.	May		June		July		Aug.		Sept.		Oct.		Nov.	Total
			16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	
Cooking Lake	1963	Adult						7	11								18
		Imm.						1	7	8			6	4			26
	1964	Adult	8	9	9	10	8	3		9	5	3					64
		Imm.							3	2	8	7	5		1		26
Hastings Lake	1963	Adult				2					4		3				9
		Imm.									5		4			3	12
	1964	Adult		10	10	8	10	7	8	5	6	3	1				68
		Imm.						1	4	3	4	8	2	6	7	2	37
Sloughs (total)	1963	Adult	1	15	14	7	12	4		2	4	8					67
		Imm.					4	12	3	9	2	7					37
	1964	Adult	1					1	2								4
		Imm.						3									3
Big Island Lake	1963	Adult		15	7		6				2	8					
		Imm.							1			7					
	1964	Adult	1					1	2								
		Imm.						3									
Cawes Lake	1963	Adult	1		7	7											
		Imm.															
Josephburg (2 1/2 mi. S)	1963	Adult					4	2		1	1						
		Imm.					3	8	1	8	1						
Misc.Sloughs Near Edmonton	1963	Adult					2	1		1	1						
		Imm.					1	1	1	1	1						
Innes Lake	1963	Adult						1									
		Imm.						3									

Figure 1. Coot Data Sheet .

No. _____ Date: _____ Sex: _____ Age: _____ Weight: _________

Location:

Method of Capture:

Total length: _____________ Tip of bill to feathers:__________

Callus length:_____ Callus width:_____ Tarsal/toe length:_____

Middle toe to tip of nail:______________ Hallux length: ______

Plumage: (type & color)

Tibia color:_______________ Tarsal color: __________________

Bursa: Length ______ Width ______ Condition __________________

Fatness: ________ Keel depth: ______ Muscle depth: ___________

Testes: Preserved (_) Weight_____ Length_____ Width __________

Ovary: Preovulatory follicles: ___ Postovulatory follicles___

Weight: ________________ Largest follicle size: ______________

Oviduct base width: ______________________

Adrenal gland:

Small intestine length: ______________ Caeca length: _________

Stomach contents:

Plant Material: weight: __________ Animal material: weight:___

Other material: weight: _____________

Remarks:

Figure 1. (continued).

Date Examined: Examiner #______

Location	#	type	species
External:			
Blood: smear			
Buccal cavity:			
Nasal cavity:			
Eyes:			
Coelom:			
Esophagus:			
Proventriculus:			
Ventriculus:			
Small intestine:			
Caeca:			
Cloaca:			
Trachea:			
Lungs:			
Airsacs:			
Liver:			
Pancreas:			
Kidney:			
Mesenteries:			
Muscles: (specify)			
Blood vessels:			
Other tissues:			
Remarks:			

organs were outlined by Gallimore (1964).

The parasites recovered from frozen birds were relaxed and could be immediately fixed in A.F.A. Cestodes and trematodes, when recovered alive, were killed and relaxed by leaving them in cold water and then fixed in A.F.A. Live nematodes were killed in hot A.F.A.

Cestodes were stained with Semichon's acetocarmine, cleared in xylene and mounted in balsam. For detailed study material was also stained with Horen's trichrome in acetic acid (Chubb, 1962) and/or Erlich's haematoxylin because of their slightly different effects on various structures.

Trematodes were originally stained in Semichon's acetocarmine; however, upon the discovery of Chubb's (1962) acetic acid-haematoxylin method all but very small trematodes were stained this way. The latter method gave excellent clarity of the reproductive system and stained the body only lightly. However, very small trematodes were found to destain before they could be mounted. Horen's trichrome in acetic acid was excellent for the ventral glands of Notocotylus. The method adopted for the latter was to stain in Horen's for a few seconds and then to examine under a binocular microscope in acetic acid. The readily visible glands were counted, the specimen destained in water and then restained in acetic acid - haematoxylin and mounted. The glands are not visible in the final preparations, nor in Horen's when permanently mounted.

Acanthocephala were easily stained in acetic acid-haematoxylin with excellent results.

Cestodes, trematodes and acanthocephala were dehydrated in acetic acid if the acid haematoxylin was used. They were then cleared by using 50:50 acetic acid:methyl salicylate followed by pure methyl salicylate (Chubb, 1962). They could be left in the latter or mounted in balsam. If other stains were used, the normal alcohol, xylene, balsam method was necessary.

Acanthocephala were also examined, with excellent results, by placing them directly from A.F.A. into creosote. Chubb (1964) recommended immersing the material in acetic acid first but for the present material this was found to be unnecessary. After examination, they were returned to A.F.A.

Nematodes were found to be mounted successfully only by the standard glycerine jelly method. For examination, temporary mounts in lactophenol were found to be the best. Methyl salicylate preparations were excellent for detailed examination of spicule morphology, but badly crushed the body of the worm. This preparation could be made permanent in balsam.

TAXONOMY

A total of 36 species of helminths, including 14 trematodes, 9 cestodes, 8 nematodes, 4 acanthocephala and 1 leech, were found in the present study. The helminths recovered and the data on their extensity (percent of the hosts infected), intensity (average number of helminths per infected host) and range of infection in adult and immature coots are given in Table II. New host and new North American records are also indicated. Hosts, location in the bird, life cycle (if known), and distribution of each parasite as taken from the literature are given. References given are to the paper from which this information was obtained and not necessarily to the original work. Any variations from the literature are discussed under each species.

The classification of Yamaguti (1958, 1959, 1961 and 1963) is used except when stated otherwise. The supra-generic classification of the trematodes used is that of LaRue (1957).

Grouped data on the extensity, intensity, and range of infections in adults and immature coots are given in Appendices I and II. Appendix I indicates extensity and intensity of parasites occurring in over 3.5% of all birds collected, and is for each half month interval of collecting. Appendix II indicates the extensity and intensity of the major parasites collected in 1963 and 1964 from Hastings Lake, Cooking Lake, and sloughs during the period of stable bird populations on these areas (16 May through 31 August).

Table II. Summary of helminths recovered from the American coot.

Species	Adult (230)			Immature (141)		
	Extensity	Intensity		Extensity	Intensity	
		Mean	Range		Mean	Range
Trematoda						
Cotylurus hebraicus (a, b)	1.7	3.8	1-7	4.9	16.7	1-55
Cyclocoelum mutabile	15.3	3.5	1-32	14.1	6.2	1-28
Cyclocoelum oculeum	20.0	1.9	1-6	11.4	2.3	1-5
Neoleucochloridium problematicum	12.6	9.9	1-91	29.0	29.8	1-270
Echinostoma attenuatum (a)	22.6	10.2	1-200	42.5	15.7	1-180
Echinostoma chloropodis	5.2	18.2	1-150	.7	1.0	1
Echinostoma revolutum	.4	3	3			
Echinostoma sp.				1.4	103.5	60-147
Hypoderaeum concoideum (a)				.7	73.0	73
Protechinostoma mucronisertulatum (imm.) (a)	.4	15	15	1.4	64.0	28-100
Ribeiroia thomasi (a)				.7	1.0	1
Notocotylus pacifera	26.5	4.4	1-21	32.4	9.8	1-60
Tanasia atra	26.9	5.5	1-24	16.3	10.3	1-45
**Orchipedum tracheicola* (a)	17.6	3.0	1-11	19.6	4.0	1-8

Table II (continued).

Species	Adult (230)			Immature (141)		
	Extensity	Intensity		Extensity	Intensity	
		Mean	Range		Mean	Range
Cestoda						
Schistocephalus solidus (a)	1.7	3.2	1-10	.7	1.0	1
Diorchis americana	6.9	13.7	1-100	15.7	7.5	1-34
Diorchis ransomi	1.7	5.8	2-14	18.5	17.2	1-150
Aploparaksis furcigera (a)				.7	1.0	1
Cloacotaenia megalops (imm.)	.4	1.0	1			
Lateriporus sp. A (imm.)	1.2	2.3	1-5			
Lateriporus sp. B (imm.)	13.0	10.3	1-64	12.0	9.9	1-50
Cestoda sp. A (imm.)	3.4	4.3	1-18	3.5	3.0	1-10
Cestoda sp. A (imm.)	1.7	78.2	3-150			
Nematoda						
Strongyloides avium	2.2	2.8	1-6	2.1	14.6	1-40
*Capillaria fulicae (a, b)	10.3	4.3	1-24			
Amidostomum fulicae	70.8	6.5	1-33	26.2	6.5	1-59
Echinuria heterobrachia (a)	.8	35.5	1-70			

Table II (continued).

Species	Adult (230)			Immature (141)		
	Extensity	Intensity		Extensity	Intensity	
		Mean	Range		Mean	Range
<u>Echinuria</u> <u>?uncinata</u> (imm.) (a)				3.5	7.8	1-24
<u>Tropisurus</u> sp.	23.9	2.8	1-19	9.2	3.6	1-18
*<u>Spirofilaria</u> <u>fulicaeatrae</u>	40.5	2.8	1-11			
<u>Streptocara</u> sp.				.7	1.0	1
Acanthocephala						
<u>Polymorphus</u> <u>trochus</u>	67.3	10.3	1-60	66.7	19.7	1-140
<u>Polymorphus</u> <u>paradoxus</u> (imm.)	20.8	2.3	1-18	18.4	1.9	1-9
<u>Polymorphus</u> spp. (imm.)	70.4	44.8	1-500	60.2	50.0	1-800
<u>Corynosoma</u> <u>?constrictum</u> (imm.)	2.1	2.2	1-5	3.5	3.2	1-8
Hirudinea						
<u>Theromyzon</u> <u>rude</u>	11.7	1.3	1-3	20.5	1.7	1-5

*= 1964 data only (94 adults, 75 immatures)

a = new host record

b = new North American record

CLASS Trematoda

ORDER Strigeatoidea

FAMILY Strigeidae

Cotylurus hebraicus Dubois, 1934

Hosts: *Fulica atra* (Dubois, 1938), *Fulica americana*.

Location: Small intestine.

Life Cycle: Metacercariae in leeches (Bychovskaya-Pavlovskaya, 1962).

Distribution: Syria (Dubois, 1938), Soviet Union (Ginetsinskaya, 1952), Germany (Odening, 1962), Alberta.

This is the first record of this species in North America. There are five other species of this genus with vitellarian follicles penetrating the forebody. Four of these, *C. erraticus* (Rudolphi, 1809), *C. gallinulae* (Lutz, 1928), *C. lintoni* Perez Vigueras, 1944, and *C. strigeliodes* Dubois, 1958, are separated from this species by having only a few follicles at the base of the forebody. *C. vitellosus* Lumsden and Zischke, 1963 has a triangular shaped mass of vitellarian follicles penetrating the forebody to the level of the acetabulum. Lumsden and Zischke distinguished their species from *C. hebraicus* by the following characters: *C. hebraicus* has a posterior segment to forebody ratio of 2.37-2.46 to 1, eggs measuring .086-.090 x .055-.065 mm and only a few scattered follicles at the level of the acetabulum; *C. vitellosus* has a posterior body to forebody ratio of 1.3-1.9 to 1, eggs measuring .092-.106 x .053-.059 mm and a dense triangular

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mass of follicles penetrating to the level of the acetabulum.

However, Odening (1962) states that the main character distinguishing _C_. _hebraicus_ is the vitellaria reaching the forebody and he gives an illustration of a dense mass of vitellaria going to the acetabulum and beyond. The ratio of the hindbody to the forebody of Odening's material is down to 1.96 and the eggs measure .065-.089 x .045-.058 mm. The material of the present study have had from a few scattered to a dense mass of vitellarian follicles reaching to the acetabulum and beyond,with a forebody to hindbody ratio reaching 1.96,and eggs reaching a maximum length of .098 mm.

It is felt, therefore, that the validity of _C_. _vitellosus_ should be re-examined; the material of Dubois (1938) and that of Lumsden and Zischke (1963) may be variants of the same species caused by geographical variation and/or host differences (_Fulica atra_ for _C_. _hebraicus_ and _Gallinula chloropus_ for _C_. _vitellosus_).

FAMILY Cyclocoelidae

Cyclocoelum mutabile (Zeder, 1800)

Hosts: _Gallinula chloropus_, _Fulica atra_, _Fulica americana_, _Fulica armillata_, _Porphyrula martinica_, _Jacana_, _Tringa_, _Vanellus_ (Dubois, 1959).

Location: Air sacs.

Life Cycle: Cercariae of _C_. _microstomum_ (Creplin, 1829) (= _C_. _mutabile_ - Dubois, 1959) develop in

snails of the genera Lymnaea and Planorbis; metacercariae encyst in the same individuals (Ginetsinskaya, 1952). Wootton (1964) was able to infect only physid snails.

Distribution: Europe, Siberia, North and South America (Dubois, 1959).

The taxonomy of this group was most recently reviewed by Dubois (1959), from whose keys the material was identified. Palm (1963) and Wootton (1964) have disagreed, but have not given reasons.

Immatures of this species were found in the livers of at least two adult coots. One, collected at Cooking Lake, July 31, 1963, had 10 specimens in the liver and two additional immatures in the intestine. (The latter may have been due to contamination with worms on the mesenteries which came off during stripping of gut contents.) The other coot, collected on August 18, 1964 at Cooking Lake, had 6 specimens in the liver. An additional coot, collected May 8, 1963 at Big Island Lake, had 2 immature cyclocoelids in the liver but they were in poor condition and their assignment to this species is questionable.

Cyclocelum oculeum (Kossack, 1911)

Hosts: Fulica atra, Porzana pusilla, Gallinula chloropus (Dubois, 1959); Fulica americana (Herber, 1961).

Location: Nasal cavity.

Life Cycle: Cercariae developed experimentally in *Radix ovata*; metacercariae encyst in same host (Palm, 1963).

Distribution: Europe, Siberia (Dubois, 1959); North America (Herber, 1961).

This species was identified from the key and description of Dubois (1959). Wootton (1964) states that he is describing a new species, *C.* (*Hyptiasmus*) *californicus,* from the nasal passage of coots in California, but does not give the description in that paper. The new description has not been located.

Herber (1961) identified a cyclocoelid from the nasal passage of a coot in El Salvador as *Hyptiasmus arcuatus*. His description, however, appears to be of *C. oculeum*, and is the first record of this parasite from *F. americana* and from North America.

Two coots collected May 8 and May 24, 1963, at Big Island Lake had immatures, apparently of this species, in the trachea.

FAMILY Brachylaemidae

Neoleucochloridium problematicum (Magrath, 1920)

Hosts: *Porzana carolina*, *Fulica americana*, *Gallinula chloropus*, *Rallus limicola* (exp.) and *Gallus domesticus* (exp.) (Kagan, 1951).

Location: Cloaca; occasionally caeca, lower intestine, or Bursa of Fabricius.

Life Cycle: Cercariae develop in Succineidae (*Oxyloma retusa* and *Quickella* sp.) and encyst in an

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outpouch of the sporocyst (Kagan, 1951, 1952a).

Distribution: Minnesota and Michigan (Kagan, 1952b); Alberta.

The present material was identified from the key in Kagan (1952b) and the description in Kagan (1951). Some specimens were larger than the maxima given by Kagan for body size, suckers, and gonads but the arrangement and proportions of these organs were the same as in his material. Kagan (1951) noted the faster development in coots than in the other hosts. The present large sample then may be expected to produce a few larger specimens.

ORDER Echinostomida

FAMILY Echinostomatidae

Echinostoma

Four species were found in the present study: Echinostoma attenuatum (Lumsden and Zischke, 1963), Echinostoma chloropodis (Zeder, 1800), Echinostoma revolutum (Frölich, 1802) and Echinostoma sp. They were readily separable on the basis of collar spines, which were, respectively, 45 with five corner spines, 47-49 with four corner spines, 37 with five corner spines, and 41-43 with five corner spines. Unfortunately, the collar spines were frequently lost, thus making the separation of the specimens difficult.

E. chloropodis was the easiest to separate using stoutness of body and neck and the four corner spines which were not readily lost. The relative size of testes to body length was also useful. E. revolutum, identified only once, was separated

from the other two species by possession of a round acetabulum and relatively small testes, which were approximately 1/20 of the body length, compared to the elongate pitcher-shaped acetabulum and elongate testes, greater than 1/12 of the body length, of Echinostoma sp. and E. attenuatum. Echinostoma sp. was identified only twice, both times by collar spines. It was generally smaller than E. attenuatum in body size but the body sizes of the two species did overlap slightly. Therefore, material listed as E. attentuatum may contain smaller numbers of Echinostoma sp. and possibly even of E. revolutum.

Echinostoma attenuatum Lumsden and Zischke, 1963 (Fig. 2,3)

Hosts: Rallus elegans (Lumsden and Zischke, 1963); Fulica americana.

Location: Small intestine.

Life Cycle: Unknown.

Distribution: Louisiana (Lumsden and Zischke, 1963); Alberta.

This species, the most frequently found Echinostoma, was found in the upper small intestine, occasionally in the lower intestine and the caeca. It was identified by comparison with the original description.

Echinostoma chloropodis (Zeder, 1800) (Fig. 3,4)

Hosts: Gallinula chloropus, Rallus aquaticus, Porzana porzana (Ginetsinskaya, 1952); Calidris testacea (Skrjabin, 1956); Ortygometra

porzana, Capella gallinago, C. media, Porzana pusilla (Yamaguti, 1958). Fulica americana (Herber, 1961).

Location: Small intestine.

Life Cycle: Unknown.

Distribution: Europe, Russia (Skrjabin, 1956); Philippines (Tubangui, 1932); El Salvador (Herber, 1961); Wisconsin (Dubois, 1951); Alberta.

Some of the present specimens were larger than previously described material, reaching a length of up to 15 mm , with a proportional increase of other measurements. In a few well preserved specimens, body spines were noted to extend to the level of the acetabulum, but these were readily lost in most specimens. Body spines have not been reported on this species in North America although Tubangui (1932) reported then on E. chloropodis recovered in the Philippines.

The material was identified from the key in Skrjabin (1956), and the descriptions of Dubois (1951), Skrjabin (1956) and Herber (1961).

Echinostoma revolutum (Frölich, 1802) (Fig. 6)

Hosts: Wide variety of birds, mainly anatids, and a few mammals, especially Ondatra zibethica (Beaver, 1937).

Location: Small intestine.

Life Cycle: Cercariae develop in snails of the genera Lymnaea, Stagnicola, Helisoma, Planorbis and

Physa; metacercariae encyst in a wide variety of snails and in tadpoles (Beaver, 1937).

Distribution: Cosmopolitan.

This species was identified by comparison with known material and the description of Beaver (1937). Three specimens were found in one adult coot shot June 21, 1963, 2-1/2 miles south of Josephburg.

Echinostoma sp. (Fig. 7,8)

Two immature coots collected July 4, 1963, 2-1/2 miles south of Josephburg were infected with approximately 60 and 140 worms of this species. These worms were partially contracted and thus measurements were difficult to make. Only the most relaxed worms were measured.

The body measured 5.6 mm x .84 mm. There were 41-43 collar spines with 5 on each corner which measured .045-.075 mm. The body was spined from the level of the collar to half way between ovary and acetabulum. The oral sucker measured .150-.185 x .135-.165 mm. A small prepharynx was present. The pharynx was .140-.160 x .095-.145 mm and lead to an esophagus of up to .180 mm long. The caeca bifurcated at the anterior margin of the acetabulum. The acetabulum measured .565-.645 x .385-.475 mm. The cirrus sac was dorsal to the acetabulum, reached to its posterior border and measured .475-.675 x .200-.270 mm; genital openings were at the bifurcation of the caeca. The vitellaria were mainly in the lateral fields, but overlapped slightly behind the testes. The anterior testis

Figure 2

<u>Echinostoma</u> <u>attenuatum</u>

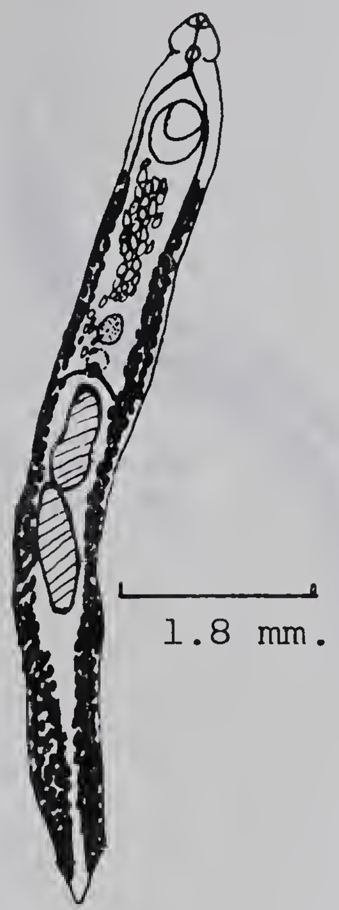


Figure 3

<u>Echinostoma</u> <u>attenuatum</u> -

collar spines.

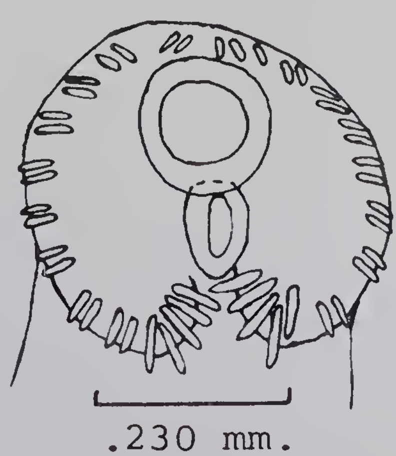


Figure 4

<u>Echinostoma</u> <u>chloropodis</u>

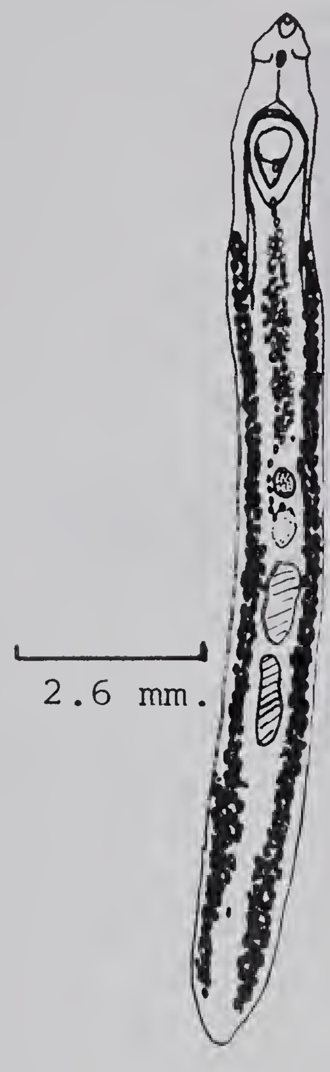


Figure 5

<u>Echinostoma</u> <u>chloropodis</u> -

collar spines.

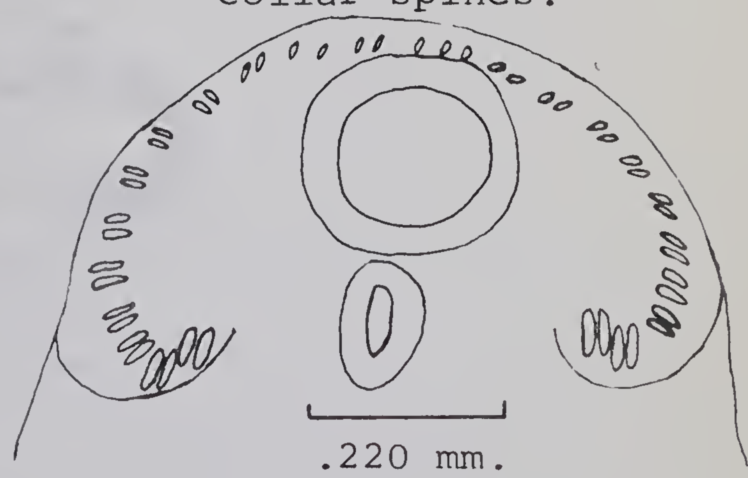


Figure 6

<u>Echinostoma</u> <u>revolutum</u>

Figure 7

<u>Echinostoma</u> sp.

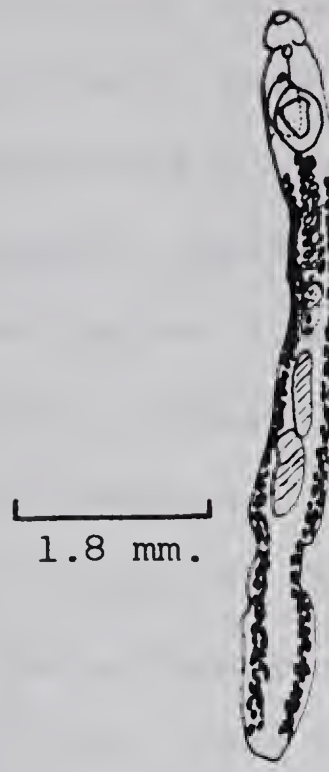


Figure 8

<u>Echinostoma</u> sp. -

collar spines.

measured .620-.880 x .160-.305 mm and posterior testis measured .645-1.017 x .180-.330 mm. The ovary measured .180-.305 mm in diameter; eggs were .098-.100 x .060-.073 mm.

There are at least six species having 41-43 collar spines. *E. cornale* Kurova, 1923 and *E. alepidatum* Dietz, 1909 have too long a body and in the latter the testes are too small in proportion to the body size for the present species. *E. academica* Skrjabin, 1915 has larger corner spines (.148 mm) and *E. turkestanicum* Kurova, 1923 has corner spines of .028-.053, which are too small for the present specimens, *E. gracile* Perez Vigueras, 1944 is similar in size but the testes are much too small (.480 x .170 mm) and the acetabulum is larger (.960 x . 810 mm). *E. sticulosum* Dietz, 1909 is very similar in measurements but appears to have only 4 corner spines. Thus none of the known species appear to resemble the present material.

Hypoderaeum conoideum (Bloch, 1782)

Hosts: Large number of Anatidae, *Gallus*, *Columba*, Podicipedidae, *Fulica atra* (McDonald, 1965), *Fulica americana*.

Location: Small intestine.

Life Cycle: Rediae and metacercariae in the genera *Planorbis*, *Lymnaea* (Yamaguti, 1958).

Distribution: Europe, Japan, Siberia (Yamaguti, 1958); Alberta.

This species was found in one immature bird shot July 4,

[illegible]

[illegible]

[illegible]

[illegible]

1963, 2 1/2 miles south of Josephburg. The 73 specimens were contracted making measuring difficult. Identification, mainly from cephalic spines, was made using the keys in Skrjabin (1964) and the description in Skrjabin (1956).

<u>Protechinostoma</u> <u>mucronisertulatum</u> Beaver, 1943

Hosts: <u>Porzana</u> <u>carolina</u> (experimentally in mice and domestic chicks) (Beaver, 1943); <u>Fulica</u> <u>americana</u>.

Location: Small intestine.

Life Cycle: Larvae develop in <u>Stagnicola</u> <u>reflexae</u> and <u>S.</u> <u>palustris</u>; metacercariae encyst in snails of the genera <u>Stagnicola</u>, <u>Lymnea</u>, <u>Physa</u>, <u>Helisoma</u> and <u>Fossaria</u> (Beaver, 1943).

Distribution: Illinois (Feldman, 1941), Wisconsin (Beaver, 1943), Iowa (Redington and Ulmer, 1964), Alberta.

Only three coots were found infected: an adult collected April 28, 1964, at Cooking Lake (15 specimens), an immature collected July 4, 1963, 2 1/2 miles south of Josephburg (100 specimens), and an immature collected October 28, 1964, at Cooking Lake (28 specimens). Only one of the worms was ovigerous and it contained just a single egg. Beaver (1943) failed to infect coots experimentally. In contrast, a sora rail (<u>Porzana</u> <u>carolina</u>) collected June 21, 1963, at Josephburg was infected with 50 worms, all containing numerous eggs.

The material was identified from Beaver's (1943) re-

description and renaming of *Psilostomum reflexae* (Feldman, 1941) (nec. Cort, 1914) and the keys in Yamaguti (1958).

FAMILY Cathaemasiidae

Ribeiroia thomasi (McMullen, 1938)

Hosts: *Casmerodius egretta*, *C. albus*, *Ardea goliath*, *Pandion haliaetus*, *Accipiter cooperii*, *Scopus umbretta* and *Megaceryle maxima* (Mettrick, 1963); *Podiceps grisegena*, *P. auritus*, *Podilymbus podiceps* and *Aechmophorus occidentalis* (Gallimore, 1964); *Fulica americana*.

Location: Esophagus, although Gallimore (1964) found it primarily in the proventriculus of grebes.

Life Cycle: Larvae develop in *Helisoma*, encyst in the lateral line canal of freshwater fish (Beaver, 1939).

Distribution: Africa, Brazil and North America (Mettrick, 1963).

One specimen was found in the proventriculus of an immature coot collected on October 14, 1964, at Hastings Lake.

Identification was made with the aid of keys in Yamaguti (1958), the description of Mettrick (1963), and a comparison with specimens identified by Gallimore (1964).

FAMILY Notocotylidae

Notocotylus pacifera (Noble, 1933)

Hosts: _Fulica americana_ (Noble, 1933), _Gallinula chloropodis_, _Fulica atra_, _Fulica leucoptera_ (Lumsden and Zischke, 1963).

Location: Caeca.

Life Cycle: Cercariae develop in _Physa fontinalis_ and encyst on any firm object (Odening, 1964a).

Distribution: North America, Europe, Argentina (Lumsden and Zischke, 1963).

I agree with Harwood (1939), Lumsden and Zischke (1963) and Odening (1964b) that _Notocotylus pacifera_ is a valid species not synonymous with _N. gibbus_ (Mehlis in Creplin, 1846). All of the present material possessed four ventral glands in the central row.

The species was identified from descriptions of Noble (1933), Harwood (1939) and Lumsden and Zischke (1963).

ORDER Plagiorchiida

FAMILY Eucotylidae

Tanasia atra (Nezlobinsky, 1926)

Hosts: _Fulica atra_, _F. americana_, _Porzana bailloni_, _Sterna hirundo_ (Sulgostowska, 1960); _Rallus elegans_, _Agelaius phoenicus_, _Cassidix mesamexicanus_ (Lumsden and Zischke, 1963).

Location: Kidney.

Life Cycle: Unknown.

[illegible]

Distribution: U.S.S.R., Macedonia, N. America and Poland (Sulgostowska, 1960).

The material from coots was identified by comparison of the specimens with descriptions by Byrd and Denton (1950), Sulgostowska (1960) and Lumsden and Zischke (1963). Only a few specimens of the present material were in good condition but the poor material did not differ in any visible respect from identifiable material.

FAMILY Orchipedidae

Orchipedum tracheicola Braun, 1901

Hosts: *Anas oidemia* (Bezubik, 1956); *Podiceps caspicus*, *P. grisegena*, *P. auritus* (worms all immature) (Gallimore, 1964); *Cygnus*, *Tadorna*, *Larus* (McDonald, 1965).

Location: Trachea and lungs.

Life Cycle: Metacercariae were found in gammarids collected in Hastings Lake, Alberta (Huebner, pers. corr.).

Distribution: Europe, North America, Asia (McDonald, 1965).

In 1963, only three worms were found, in birds collected May 6, 8 and 21 at Big Island Lake. In 1964, they were a common parasite of the coots with seasonal data (for 1964 only) given in Appendix I. The difference between the years is believed to be due to technique. Early in 1964, I discovered that these worms stain red from blood collecting in the lungs and trachea after the birds were shot. The worms then resemble blood clots and can only be separated by careful examination.

[illegible]

The distribution data are not given in Appendix II, as all birds collected after July 1, 1964, were from Hastings Lake.

This species was identified from the keys in Skrjabin (1964) and the description in Bezubik (1956). Most of the specimens collected were not producing eggs and were small in size.

CLASS Cestoda

ORDER Pseudophylidea

FAMILY Diphyllobothridae

Schistocephalus solidus (Mueller, 1776)

Hosts: Wide variety of fish-eating birds. No previous record in *Fulica americana*.

Location: Small intestine and caeca.

Life Cycle: Procercoid in *Cyclops vernalis*; plerocercoid in *Cottus*, *Gasterosteus*, *Salvelinus*, *Uronidea*, *Pygosteus* etc. (Yamaguti, 1959).

Distribution: Cosmopolitan.

This parasite was recovered five times. Single worms were found in an adult collected on August 30, plus two adults and an immature collected on September 4, 1963, all from Big Island Lake. Ten worms were recovered from an adult collected May 7, 1964, from Hastings Lake.

This parasite was identified from keys in Yamaguti (1959).

ORDER Cyclophyllidea

FAMILY Hymenolepididae

Diorchis

Two species of this genus were found in the present study; they were readily separable on the basis of hook size, cirrus morphology, and strobila length and width. *Diorchis americana* has a rostellum with 10 hooks .065 mm long, a thin cirrus .060 mm long with minute spines and a small bulb at the base, and a gravid strobila approximately 50 mm in length by 1 mm in width. *Diorchis ransomi* has a rostellum with 10 hooks .037 - .040 mm long, a stout cirrus up to .190 mm long with a large spined basal bulb and a gravid strobila approximately 60 to 125 mm long by 1.4 - 2.1 mm wide.

Diorchis americana Ransom, 1909 (Fig. 9)

Hosts: *Fulica americana* (Ransom, 1909); *Gallus gallus*, *Dendrocitta* sp., *Gallinula chloropodis*, *Fulica atra* (Yamaguti, 1959).

Location: Small intestine.

Life Cycle: Unknown. Ostracods and sometimes also copepods were found to be intermediate hosts of 6 other species of *Diorchis* by Rybicka (1957a,b) and Jarecka (1958a).

Distribution: Nebraska (Ransom, 1909), India and France (Yamaguti, 1959).

Three species of *Diorchis*, *D. americana* Ransom, 1909, *D.*

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Figure 9

<u>Diorchis</u> <u>americana</u> - terminal genitalia

(two specimens).

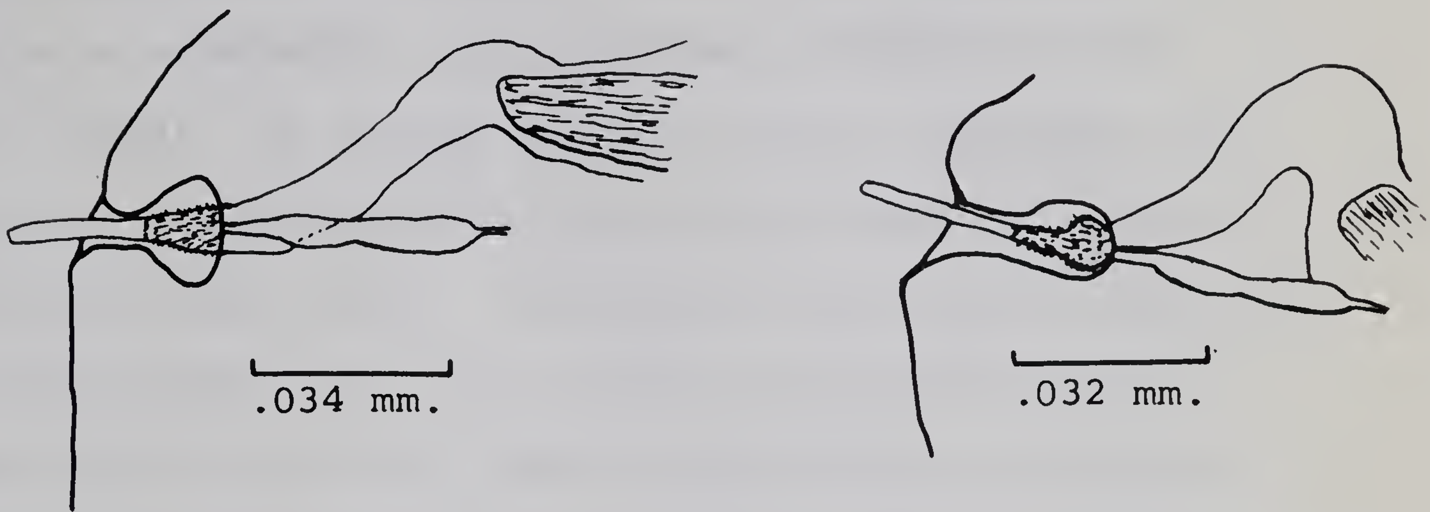


Figure 10

<u>Lateriporus</u> sp. A -

scolex .

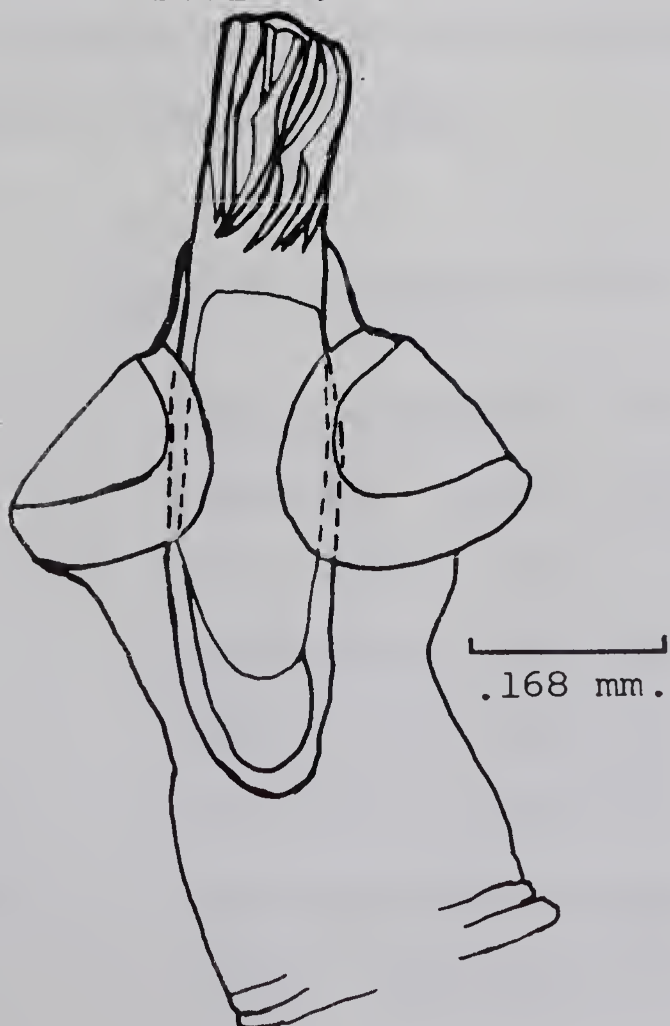
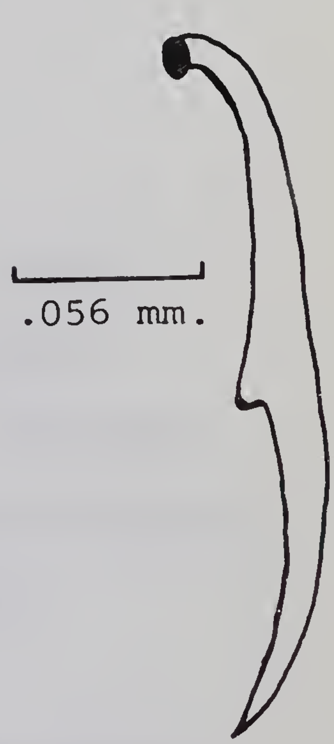


Figure 11

<u>Lateriporus</u> sp. A -

rostellar hook .



turkestanica Skrjabin, 1914, and _D_. _brevis_ Rybicka, 1957, are very similar in morphology. _D_. _americana_ and _D_. _turkestanica_ differ only by the presence of a vaginal bulb reaching .090 mm in diameter in the latter, which was originally described as a subspecies and was raised to species level by Schultz (1940). _D_. _brevis_ differs from _D_. _americana_ only by having a cirrus with spines and a bulb, which are supposed to be lacking in the latter. My material has a small chitinous vaginal bulb of about .045 mm, a cirrus with minute spines and a small bulb, the latter smaller than that in _D_. _brevis_. Because these characters are intermediate between those of _D_. _americana_ and those of _D_. _turkestancica_ or _D_. _brevis_, it is my opinion that these three species should be re-examined to determine if they are separate species or geographical variates.

The present material was identified from the original description of Ransom (1909).

Diorchis _ransomi_ Schultz, 1940

Hosts: _Fulica_ _americana_ (Ransom, 1909); _Aythya_ _americana_, _Nyroca_ _ferina_, _Nyroca_ _rufa_ (Czaplinski, 1956); _Fulica_ _atra_, _Gallinula_ _chloropodis_ (Rybicka, 1957a); _Aythya_ _fuligula_ (imm. worms) (Beverly-Burton, 1964).

Location: Lower small intestine.

Life Cycle: Cysticercoids in _Cypridopsis_ _vidua_ and _C_. _levis_. Extensive studies on the life cycle

and development of this species were carried by Rybicka (1957a, 1957b, 1960, 1961).

Distribution: Nebraska (Ransom, 1909), Iowa (Roudabush, 1940), Russia and Siberia (Czaplinski, 1956), Poland (Rybicka, 1957a), England (Beverley-Burton, 1964), Alberta.

D. ransomi was originally named by Schultz (1940) for Ransom's (1909) description of "*Diorchis acuminata*" Clerc, 1903, without separation from the latter species being given. The species was then separated by Schultz (1940) from *D. longibursa* Steelman, 1939, which differs from *D. ransomi* in only two characters: one is the length of strobila (used in Schultz's key), the other is the length of the cirrus pouch. Both original descriptions were from non-gravid strobilae and thus the strobilar length was an invalid character. Recently Czaplinski (1956) and Rybicka (1957a) have given measurements for *D. ransomi* that completely overlap the differences in the species. Table III compares these measurements.

I therefore feel that *D. ransomi* is probably a synonym of *D. longibursa*, but since the type material of the two species has not been compared, I will use the currently accepted name, *D. ransomi*.

This material was identified from descriptions in Ransom (1909), Czaplinski (1956) and Rybicka (1957a).

Table III. Comparative measurements of *Diorchis ransomi* and *D. longibursa*. All measurements in mm.

	Diorchis ransomi				*D. longibursa*
	Ransom (1909)	Czaplinski (1956)	Rybica (1957)	*Present Study	Steelman (1939)
Strobila length	35.0	135-164	150-200	60-125	33-86.5
Stobila width	.65	1.8-2.5	1.5-2.0	1.4-2.1	1.15
Scolex width	.225-.235	.290-.380	.230	.153-.305	.240
Rostellum length	.100	.130-.180			.200
Tip width	.070	.085	.060	.052-.079	.080
Hook length	.038	37.7-40.6	.035-.038	.037-.040	.0367
Testis	.100-.130	.130-.165	.100-.130	.105-.170	
Cirrus sac length	.180-.280	.480-.620	.20-.37	.320-.620	.560
Cirrus sac width	.045-.055	.45-.60	.045	.050-.065	.040
Cirrus	.150	.184	.100-.12	.060-.190	.200
Cirrus bulb	.16	.16-.18		.012-.020	.019
Onchosphere length			.014-.046	.034-.040	
2nd shell length			.229-.314	.210-.275	

* Measurements include material of Dr. R. Rausch collected at Buckeye Lake, Ohio, U. S. A.

Aploparaksis furcigera (Rudolphi, 1819)

Hosts: Wide variety of Anatidae (Czaplinski, 1956); *Fulica atra* (McDonald, 1965); *Fulica americana*.

Location: Small intestine.

Life Cycle: Unknown.

Distribution: Europe, Asia, America (Czaplinski, 1956).

One badly damaged gravid specimen was recovered from an immature coot collected June 14, 1964, at Big Island Lake. Positive identification could be made from hook, scolex, and cirrus morphology as illustrated and described by Czaplinski (1956).

Cloacataenia megalops (Nitzsch in Creplin, 1829)

Hosts: Wide range of Anatidae, *Fulica americana* McDonald, 1965).

Location: Cloaca.

Life Cycle: Cysticercoids in ostracods (Jarecka, 1958a).

Distribution: Cosmopolitan.

One specimen, mature but without eggs, was found in the intestine of an adult coot collected August 6, 1964, at Cooking Lake. The specimen was identified by comparison with previously identified material and the description of Czaplinski (1956).

FAMILY Dilepididae

Lateriporus

Two species, apparently belonging to this genus, were found in this survey, always in a very immature condition. They were identified to this genus by the number, size and morphology of hooks as well as the scolex morphology.

Lateriporus sp. A (Fig. 10,11)

The worms reached a length of about 10 mm with only the primordia of genitalia appearing. The scolex was .460-.475 mm wide with four unarmed suckers .215 mm in diameter. No completely everted rostellum was found. There were 16 rostellar hooks, .208-.214 mm in length. The neck was .226-.305 mm wide. Gallimore (1964) reported a single mature *Lateriporus* sp. from *Podiceps grisegena* of similar morphology and measurements. This species was found in three adult coots, one collected at Big Island Lake, May 15, 1963 (1 specimen) and two collected at Hastings Lake on May 19, 1964 (5 and 1 specimens).

Lateriporus sp. B (Fig. 12,13)

This species reached a maximum length of about 3 mm and no primordia of genitalia were observed. The scolex was .385-.475 mm wide with 4 unarmed suckers .205-.300 mm in diameter. The rostellum was .340-.440 mm long by .90-.110 mm wide at the tip with 14 hooks(15 in one of 9 scolices)

.168-.183 mm in length. The neck was .205-.260 mm wide. Gallimore (1964) reported a similar immature Lateriporus sp. in Podiceps grisegena and P. caspicus.

Cyclophyllidea incertae sedis

Cestode A (Fig. 14,15)

This cestode species never passed beyond a very immature condition in coots. The scolex was .680-.730 mm wide with four unarmed suckers .270-.340 mm in diameter. The rostellum was .395-.430 mm long by .225 mm wide at the tip, with a rostellar sac 1.000 to 1.020 mm long. There were ten rostellar hooks .238-.259 mm in length. The neck measures .485-.510 mm in width. Thus far, this cestode has not been identified.

Cestode B (Fig. 16,17)

This species of cestode was also found in a very immature condition only. The scolex was .150-.175 mm wide with four unarmed suckers .65-.75 mm in diameter. The rostellum was .128-.147 mm long and .73-.76 mm wide at the tip with a rostellar sac .330-.370 mm long. There were ten (11 in one out of 8) rostellar hooks .046-.050 mm long. The neck was .060-.100 mm wide. This parasite was found in four adult birds collected in 1964. Two were collected on Cooking Lake on May 26th and June 6th each with 150 worms present. Two were collected on Hastings Lake on June 22 with 10 and 3 worms each. This parasite may have been over-looked if it occurred in small numbers due to the small size (less than 1 mm in length).

[illegible]

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[illegible]

[illegible]

[illegible]

Figure 12

<u>Lateriporus</u> sp. B - scolex.

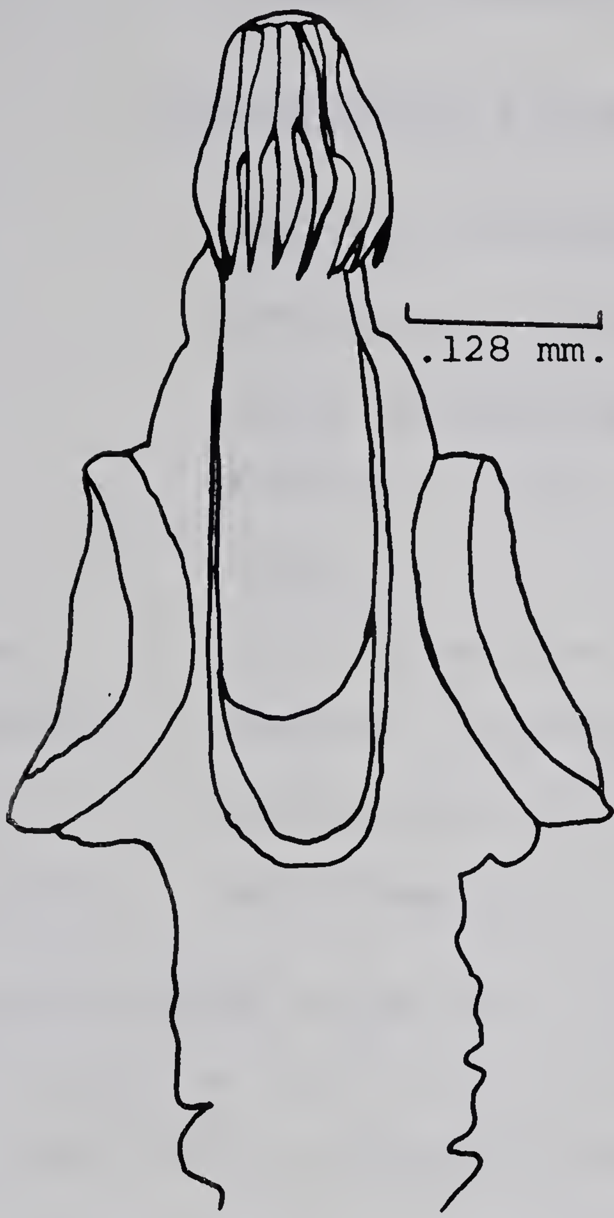


Figure 13

<u>Lateriporus</u> sp. B -

rostellar hook.

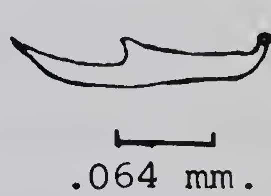


Figure 14

Cestode sp. A - scolex

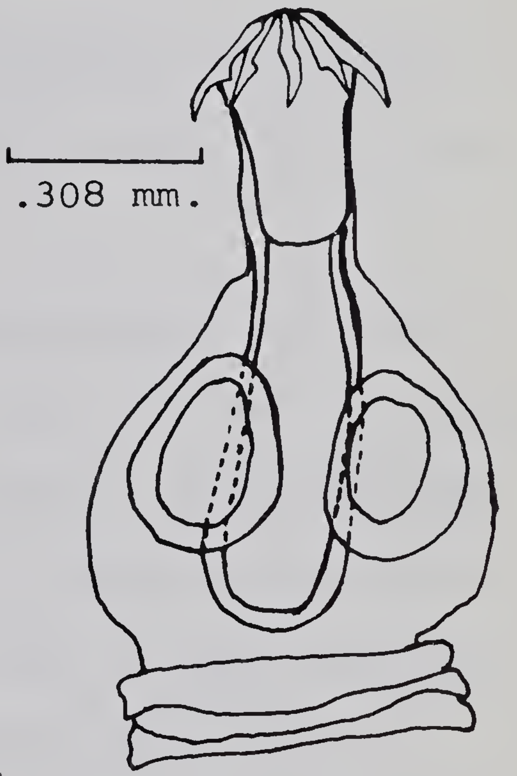


Figure 15

Cestode sp. A -

rostellar hook.

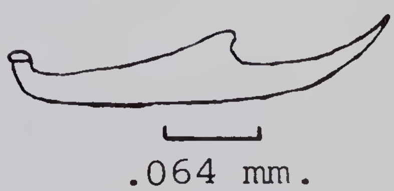


Figure 16

Cestode sp. B - scolex.

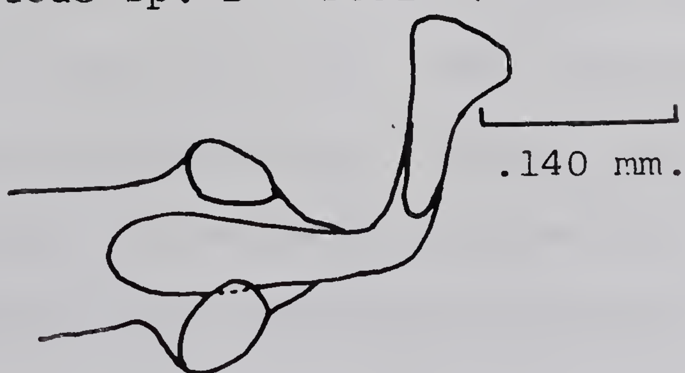
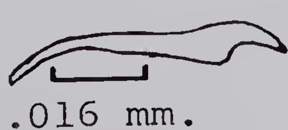


Figure 17

Cestode sp. B -

rostellar hook.



CLASS Nematoda

ORDER Rhabdiasidea

FAMILY Strongyloididae

Strongyloides avium Cram, 1929

Hosts: Domestic chickens, Junco hyemalis and Fulica americana, experimentally in Colinus virginianus, Meleagris gallapavo, Bonasa umbellus, (Yamaguti, 1961); Anas platyrhynchos (McDonald, 1965).

Location: Small intestine.

Life Cycle: Unknown. Other Strongyloides have a direct life cycle with free living forms in the soil.

Distribution: North America.

Strongyloides avium Cram, 1929, was probably overlooked on many occasions due to its very small size. It was collected only in 1964 but was probably present in 1963. Strongyloides avium occurred in five adults collected on May 23 and June 6, 1964, from Cooking Lake and on June 22, July 28 and September 24, 1964, from Hastings Lake. The infection rate was 1, 1, 6, 5 and 1 worm respectively. Three young collected July 16, 1964, from Cooking Lake were infected with 1, 3 and 40 worms.

This parasite was identified from the description in Kasimov (1956).

ORDER Trichuridea

FAMILY Trichuridae

Capillaria (=Thominx) fulicae (Pavlov and Borgarenko, 1959)

Hosts: Fulica atra (Pavlov and Borgarenko, 1959), Fulica americana.

Location: Caeca

Life Cycle: Unknown. Other known life cycles are direct or have larvae in earthworms.

Distribution: U.S.S.R. (Pavlov and Borgarenko, 1959), Alberta.

This parasite was found only in adult birds from Cooking and Hastings Lakes collected in 1964 but may have been overlooked previously. The fact that the first were found on June 6, 1964, should be viewed with reservation, but after this date a careful check was made for them. This species was identified from the description of Pavlov and Borgarenko (1959).

ORDER Strongylidea

FAMILY Strongylidae

Amidostomum fulicae (Rudolphi, 1819)

Hosts: Fulica americana (Gullion, 1952a); Fulica atra, Fulica sp., Porzana porzana, Nyroca rufa (Czaplinski, 1962a).

Location: Under ventriculus lining; rarely in the trachea and intestine.

Life Cycle: Direct; infective larvae ingested (Barus, 1964; Leiby and Olsen, 1965).

Distribution: Europe, Siberia and North America (Czaplinski, 1962a).

In his revision of the genus *Amidostomum*, Czaplinski (1962a) followed Pavlov (1960) in synonymizing *A. raillieti* Skrjabin, 1915 with *A. fulicae* (Rudolphi, 1819). However, Leiby (1964), Leiby and Olsen (1965) and Barus (1964), apparently unaware of Czaplinski's revision, used *A. raillieti*. In addition, Roudabush's (1940) record of *A. chevreaxi* (=*A. acutum*) is probably also *A. fulicae* (based on the spicule measurements).

ORDER Spiruridea

FAMILY Acuariidae

Echinuria heterobrachia Wehr, 1937

Hosts: *Larus californicus* (Wehr, 1937); *Fulica americana*.

Location: Proventriculus.

Life Cycle: Unknown. Freshwater crustacea (e.g., *Daphnia*) have been implicated as hosts in other species.

Distribution: California and Oregon (Wehr, 1937); Alberta.

This parasite was identified for me by Dr. E. E. Wehr from one adult coot infected with about 70 worms collected May 8, 1963 at Big Island Lake. However, an adult coot collected June 6, 1964 at Cooking Lake had one adult female

worm closely resembling this species. The male was 3.85 x .150 mm with cordons .350 mm in length. The buccal capsule measured .122 mm; the esophagus measured .245 and 1.350 for anterior and posterior parts respectively. The long spicule was .295 mm, the short spicule was not measured. The females measured 4.50-7.00 x .146 mm. The cordon was .325-.440 long. The buccal capsule was .110-.112 mm with esophagus .300-.325 mm and 1.23-1.30 mm for anterior and posterior parts respectively. The anus was .122 mm from the posterior end and the vulva was 1.020-1.20 mm from the posterior end. The eggs were .080-.040 x .015-.018 mm. These measurements were included because they were larger than those of the original description.

Echinuria ?uncinata (Rudolphi, 1819)

Hosts:	Large variety of Anatidae, Philomachus (McDonald, 1965); Fulica americana.
Location:	Gizzard, proventriculus, esophagus.
Life Cycle:	Larvae in Daphnia (McDonald, 1965).
Distribution:	Europe, Asia, Africa, North America (McDonald, 1965).

E. ?uncinata was collected from five immature coots; two collected on July 16, 1964 at Cooking Lake had 3 and 5 worms, and three more collected September 24, October 27, and November 6, 1964 from Hastings Lake had 1, 24 and 6 worms. They were identified mainly by comparison of spicule morphology (important characteristics in this genus according to Wehr, personal

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communication) with that shown by Czaplinski (1962b). This species did not mature in coots and was smaller than previously described material, but the measurements appeared to be proportional to those of E. uncinata given by Czaplinski (1962b). The smaller measurements may well be due to development in an abnormal host.

FAMILY Tropisuridae

Tropisurus sp. (= Tetrameres sp.) (Fig. 18)

A species of Tropisurus was a common parasite of the proventriculus. Males of this species have a single spicule, shorter than that of other single-spicule species: T. nouveli (Seurat, 1914) and T. pattersoni (Cram, 1933). T. puchovi (Guschanskaya, 1949) has been described from Fulica atra in Russia, but a description had not been seen by the present author at the time of writing. The description given below is based on 4 males and abundant female material.

The males were 2.24-4.08 x .14-.16 mm. There were four rows of spines .030-.034 mm long at the anterior end, becoming much reduced in size and number towards the posterior end of the body. The anterior digestive tract measurements were: buccal capsule .012 x .015-.021 mm, pharynx .260-.300 mm and esophagus .543-.645 mm with nerve ring .175-.180 mm from the anterior end of the body. The cloaca was .079-.153 mm from the tip of the tail. There appeared to be five spines posterior to the cloaca and five lateral spines but numbers could not be determined with certainty. There was only one

[illegible]

[illegible]

[illegible]

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[illegible]

Figure 18

Tropisurus sp. - male

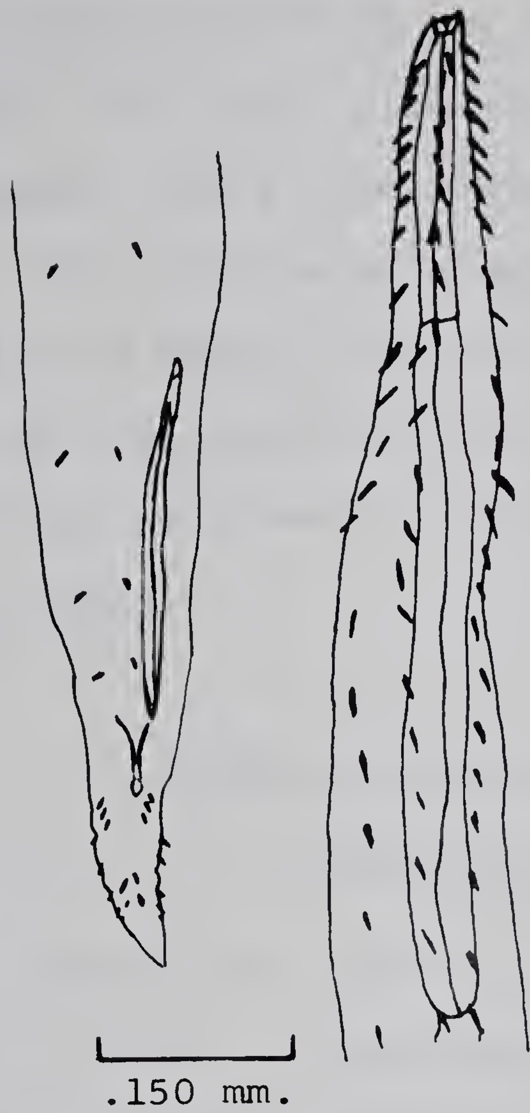
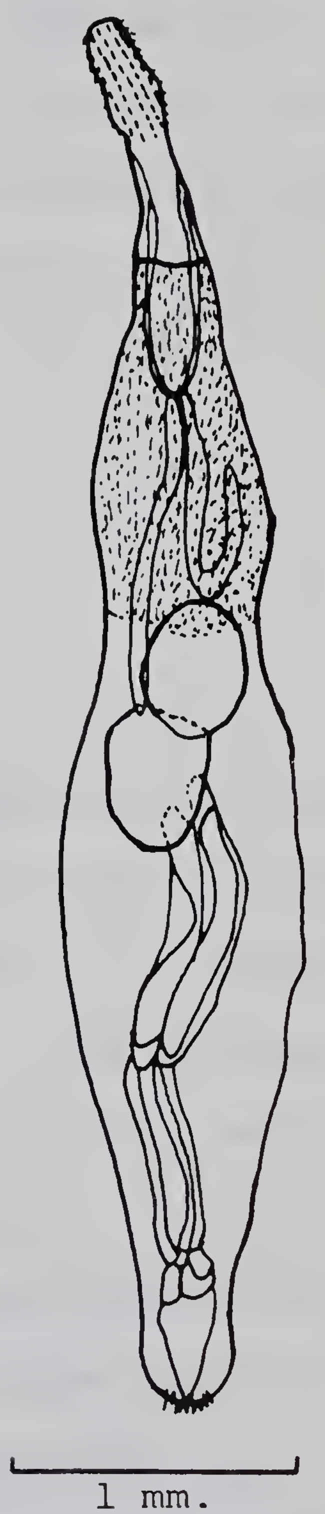


Figure 19

Measurements of acanthocephalan proboscis hooks (after Lundstrom, 1942)

Figure 20

Corynosoma ?constrictum - male



spicule, .233-.260 mm long. The cloaca walls were weakly chitinized for .034-.046 mm from cloaca opening. The females were 2.20-4.40 x 1.30-2.80 mm; no spines were observed on the females. The upper digestive tract measurements were: buccal capsule .015 x .009-.0012 mm, pharynx .750-.269 and esophagus .937-1.200 mm with nerve ring .131-.168 mm from anterior tip of body. The anus, filled with detritus, was .106-.144 mm from the tip of the tail. The opening was thick walled and may have obscured the vulva; no other openings could be located.

FAMILY Physalopteridae

Streptocara sp.

This species was found in a young coot collected on September 24, 1964, at Hastings Lake. One specimen was found in a dark detritus-filled cyst on the surface of the proventriculus. Similar cysts had been noted previously on occasion but had not been examined carefully enough to find the worm.

The parasite was identified by comparison with a worm found in a similar cyst in Podiceps caspicus by J. R. Gallimore and with descriptions in Cram (1927). Gallimore (1964) found Streptocara crassicauda to be a common parasite in the lumen of the proventriculus or under the gizzard lining of grebes in Alberta. Thus this worm is in an abnormal location. The specimen was not in good condition, the head appeared to be partially destroyed, perhaps by a host reaction. For this reason it is not identified specifically, although it was the same in all measureable respects as S. crassicauda.

ORDER Filariidea

FAMILY Filariidae

Spirofilaria fulicaeatrae (Diesing, 1861)

Hosts: *Fulica atra*, *Podiceps ruficollis* (Yamaguti, 1961); *Podiceps grisegena* (Gallimore, 1964); *Fulica americana*.

Habitat: Tarsal joint of leg.

Life Cycle: Unknown.

Distribution: Japan, Europe (Yamaguti, 1961), North America (Gallimore, 1964).

Baylis (1944) and Gallimore (1964) synonymize *S. podicipitis* Yamaguti, 1941 with *S. fulicaeatrae* (Diesing, 1861). This is thus a monotypic genus and present material was identified from keys to genera in Yamaguti (1961) and the description of *S. podicipitis* by Yamaguti (1941).

CLASS Acanthocephala

ORDER Echinorhynchidea

FAMILY Polymorphidae

Polymorphus trochus Van Cleave, 1945

Hosts: *Fulica americana* (Van Cleave, 1945a); *Anas platyrhynchos* (Priebe, 1952)

Location: Lower small intestine, large intestine and occasionally caeca.

Life Cycle: Unknown.

Distribution: North America.

This species was identifiable by the characteristic form of the proboscis of the mature female (Van Cleave, 1945a) and by the size of the hooks and eggs. Measurements of my material differed somewhat from the original description. These measurements, plus the hook formula (20-22 x 10 according to Petrotchenko, 1958, but not given in the original description) are given in Table IV.

Polymorphus paradoxus Connell and Corner, 1957

Hosts: *Castor canadensis*, *Ondatra zibethica* and *Fulica americana* (immature worms) (Connell and Corner, 1957); *Podiceps caspicus*, *P. auritus*, *P. grisegena*, and *Aechmophorus occidentalis* (Gallimore, 1964).

Location: Intestine and caeca.

Life Cycle: Cystacanths in gammarids (Connell and Corner, 1957).

Distribution: Alberta.

This parasite was always immature, except for one male which appeared to be fully developed and fell into the range of measurements given by Connell and Corner (1957). Gallimore (1964) found this species to be a major parasite of grebes, which extended its host range from mammals to birds.

Table IV. Measurements of Polymorphus trochus. All measurements in mm; hook measurements made according to the method of Lundstrom (1942) (Figure 19).

	Van Cleave, 1945a		Present Study	
	Males	Females	Males	Females
Body	3.8	4.5-7.8	2.8-3.8 x.3-1.0	4.6-7.4 z.8-1.5
Neck	.4-1.1	.35-.54	.33-.51 x.23-.36	.45-.86 x.23-.36
Proboscis	.39-.56 x.21	.38-.56 x.30-.49	.40-.48 x.21	.40-46 .31-.39
Hook Formula			20x10-12	20x10-11
First Tip Hook	.021-.042	.021-.042	.042-.043	.040-.046
Longest Hook			.046-.049	.046-.049
Basal Hook	.021-.035	.021-.035	.032-.041	.037-.046
Proboscis Sac			.78-1.09 x.13-.20	1.24-1.64 x.17-.38
Cuticular Spines			.028-.034	.028-.034
Testis			.34-.77	
Bursa Copulatrix			.24-.40	
Eggs		.075-.084 x.014-.020		.076-.095 x.016-.018

Polymorphus spp.

This group, including several species of parasites, was one of the most frequently found. Most specimens appeared to be excysted juveniles, but occasionally they would be elongated, with well developed testes in males and ovarian balls, but no eggs, in females. Measurements of elongated representatives of three groups are given in Table V. Because the sex of the worms could not always be determined the sexes are not separated in the table.

Bezubik (1957) follows Bychovskaya (1948) in synonymizing *P. magnus* Skrjabin, 1913 with *P. minutus* (Goeze, 1782). From his new description the material of Group A and C appears to be *Polymorphus minutus* but without measurements of adults, a positive conclusion cannot be drawn. *P. marilis* Van Cleave, 1939 has been reported in Alberta by Connell and Corner (1957) but it is difficult to distinguish from *P. minutus*. *P. obtusus* Van Cleave, 1918, redescribed by Ward (1943), was reported from coots in Washington by Priebe (1952). Although it has 14 - 16 rows of hooks with 7-10 hooks per row, the basal hooks measure .066 to .079, much larger than those found here.

The group in column B appears to resemble *Polymorphus contortus* (Bremser, 1821) as described by Bezubik (1957); however the hooks were up to .046 mm in length and the number of rows was up to 18 compared to only .040 mm and 16 rows in *P. contortus*. *Polymorphus acutis* Van Cleave and Starrett, 1940, reported in *Fulica americana*, has 16 rows of similar-sized hooks but there are 11-12 hooks per row.

Table V. Measurements of *Polymorphus* spp. All measurements in mm.

	Group A	Group B	Group C
No. Measured	12	4	1
Body	1.0-4.4 x.4-.7	1.4-2.2 x.4-.6	3.1x.8
Neck	.28-.53 x.14-.34	.32-.37 .16-.28	
Proboscis	.340-.565 x.160-.250	.27-.30 x.5-.18	.46x.23
Hook Formula	15-16x7-9	16-18x8	14x9
Tip Hook	.038-.062	.034-.040	.60
Longest Hook	.055-.079	.040-.046	.79
Basal Hook	.037-.061	.025-.033	.43
Proboscis Sac	.46-.86 x.08-.18	.37-.51 x.12-.15	.72x.25
Cuticular Spines	.021-.028	.022-.027	.033
Testis	.13-.56	.15-.18	.27
Bursa Copulatrix	.26-.28		.27
Cement Glands	4	4	4

Corynosoma ?constrictum Van Cleave, 1918

Hosts: Anatidae, *Fulica americana*, *Mustela vison* (McDonald, 1965).

Location: Intestine.

Life Cycle: Unknown.

Distribution: North America (McDonald, 1965).

This species occurred in the intestine and caeca and was always immature. Testes developed in the males and ovarian balls, but no eggs, developed in the females. Measurements of representative specimens are given in Table VI. The body spine pattern appeared to cover the complete upper one-third of the body (Fig.20), similar to the spine pattern shown for *C. constrictum* by Van Cleave, 1918. In the original description, Van Cleave states that *C. constrictum* has 16 rows of hooks on the proboscis, with 10-12 hooks per row, but in the discussion of the description of *Corynosoma anatarium* Van Cleave, 1945, it was stated that *C. constrictum* had 2-4 more rows than the 14 rows of the new species. Thus it appears that *C. constrictum* could have 16 to 18 rows. Because of these similarities the material has been tentatively identified as *C. constrictum*. Van Cleave (1945b) reported *C. constrictum* from coots in Ohio and Priebe (1952) reported *Corynosoma* sp. from coots in Washington but neither state whether the specimens were mature.

Table VI. Measurements of *Corynosoma ?constrictum*. All measurements in mm.

Structures	Males (5)	Females (5)
Body	3.5-5.0 x.6-1.0	3.4-4.9 x.5-1.0
Neck	.42x.25	.41-.44 x.23-.39
Proboscis	.43-.49 x.17x.20	.30-.48 x.18-.22
Hook Formula	18-19x9-11	18-19x9x11
First Tip Hook	.031-.043	.037-.040
Longest Hook	.046-,052	.046-.052
Basal Hook	.035-.040	.037-.043
Proboscis Sac	.34-.86 x.16-.18	.55-.80 x.16-.20
Cuticular Spines	.025-.034	.028-.034
Testis	.30-.60	
Caudal Spines	.034-.037	.025-.040

CLASS Hirudinea

ORDER Rhynchobdellida

FAMILY Glossiphoniidae

Theromyzon rude (Baird, 1863)

Hosts: *Anas platyrhynchos*, *Podiceps auritus*, *P. grisegena*, *P. nigricollis*, *Podilymbus podiceps* (Moore, 1964); *Anas acuta*, *Aythya affinis*, *Oxyura jamaicensis* (McDonald, 1965); *Spatula clypeata*, *Anas strepera* (Moore, pers. comm.).

Location: Nasal cavity.

Life Cycle: Unknown. Direct in other members of genus (McDonald, 1965).

Distribution: North America (McDonald, 1965).

This species was identified for me by J. E. Moore, although not all specimens were identifiable to species (due to the condition of the material). It is possible that there are other species present, since *T. occidentale* (Verrill, 1874) (= *T. meyeri* of Moore, 1964) was described from North America and has been reported from *Fulica americana*, and *T. tessulatum* (Müller, 1774) has been reported from *Fulica atra* in Europe and from other waterfowl in North America (McDonald, 1965). However, all the material has been listed as *T. rude*.

SPECIFICITY

Many helminths tend to be limited to a narrow range of hosts. Within this range all hosts are not equally satisfactory. In order to better understand the host-parasite relations involved a categorization of hosts is useful. Four authors, Sulgostowska (1958), Michajłow (1959), Dogiel (1964), and Gallimore (1964), deal with this problem.

Michajłow's system, based on experimental work, is not applicable to field data. Sulgostowska's system, consisting of only two categories, is too simple and obscures some of the information available. Further discussion of these systems, and the reasons for rejecting them, can be found in Gallimore (1964).

Gallimore (1964) expanded Sulgostowska's two classes into four which he defines as follows:

Main host: hosts in which the intensity and extensity of occurrence are relatively the highest.

Auxiliary host: hosts invaded less frequently and by a smaller number of helminths.

Accidental host: hosts invaded on rare occasions by very few helminths.

Inhibitory hosts: hosts in which the helminths do not mature.

Dogiel (1964) used three classes, defined as follows:

Main host: the parasite grows the largest, produces the most eggs, and appears to be best adapted to this host, suffering no ill effect from the restraining influences of the host.

Secondary host: although present, the parasite is less common, less abundant, growth is retarded and it meets with considerable host resistance.

Accidental or non-specific: in these hosts the parasite occurs only rarely and develops with difficulty.

Dogiel's classification is based on physical characters of the parasite as well as numbers. These characters, such as the size of the parasite, egg production and period of maturation have certain drawbacks, for the effects of nutrition (Read, 1959) and population density of helminths (Read, 1959; Korpaczewska, 1963a) affect the above characters to a considerable extent in the main host. Thus, under crowded conditions of parasites and/or poor nutritional intake by a host, a wrong impression of the type of host may occur.

The main hosts in the two classifications are probably the same. Dogiel's secondary appears to equal Gallimore's auxiliary and Dogiel's accidental would include Gallimore's inhibitory and accidental classes. The latter may be questionable. For present study Gallimore's classification is used.

Certain problems arise in placing parasites in these categories. One problem is posed by parasites with a wide specificity, making designation of major host difficult, as in Schistocephalus solidus. Dogiel (1964) points out that in many cases parasites are most specific when the greatest development of their structure is taking place. Thus in some metacercariae, such as those of Notocotylus where little development occurs, the metacercariae may encyst on a wide

range of hosts or objects, but the adults are generally quite specific. In Schistocephalus, the plerocercoid undergoes a great deal of development, and occurs mainly in one fish, the stickleback, reaching almost adult proportions. The adult worm is almost non-specific, developing in a wide variety of hosts.

A second problem was the trematode Orchipedum tracheicola, in which a few worms produced eggs, but the majority did not mature, thus overlapping the inhibitory and auxiliary classes of Gallimore's classification. As this species appears to be an exception to the system it is probably best designated as an inhibitory-auxiliary parasite of coots.

A third problem was represented by Cotylurus hebraicus which was found in low extensity and intensity suggesting an auxiliary host relationship. However, other hosts for C. hebraicus on this continent are not known; the coot appears to be the main host. It may be that this region is on the northern limits of its range and it would be more abundant in southerly regions.

I have attempted to place the 36 species of helminths found in this study into the four classes of Gallimore (1964). The type of hosts the coot represents for each helminth species plus other hosts of the species and the genera represented are given in Table VII. The coot appears to be a main host of 14 of the 36 species, an auxiliary host of 4, an accidental host of 6 others, and an inhibitory host of 12 species.

In 12 of the 14 helminths for which the coot is a main host, other hosts in which normal development occurred were

rallid birds. There have been other hosts recorded for some of these species, but in all cases where information on development was given, they were not main hosts. The other two species were *Tropisurus* sp. where no other hosts are known and *Spirofilaria fulicaeatrae* which is also reported to mature in large numbers in grebes of the genus *Podiceps* (Gallimore, 1964). It is interesting to note that Yamaguti (1961) maintained *S. podicipitis* of grebes as distinct from *S. fulicaeatrae* of coots. Thus it can be said that those helminths for which the coot is a main host, and which are therefore characteristic of coots, are generally specific to the Rallidae, mainly to coots or ecologically closely associated species of this family. It is also interesting that 7 of the 14 species for which the coot is the main host are trematodes. This agrees with Ginetsinskaja (1952) who found trematodes predominated in coots (*Fulica atra*) of Astrakhan Reserve (Volga Delta) of U.S.S.R. In contrast Sulgostowska (1958) found cestodes to predominate among the helminths of coots (*F. atra*) from Druzno Lake in Poland.

The coot is an auxiliary host of four helminths. The main host of one of these, *Echinostoma chloropodis*, is *Gallinula*, another member of the Rallidae. The other three are found in a wide variety of birds.

Four of the six helminths for which the coot is an accidental host are found in a wide variety of birds. The remaining species, *Echinostoma* sp. and *Echinuria heterobrachiata* are from genera of wide specificity. Thus the coot is an auxiliary or accidental host of helminths that appear to have

wide physiological tolerances.

The coot is an inhibitory host of 12 (33%) of the 36 helminths found. Of the four that could be identified to species, one has another rallid as a main host, two are widely distributed in anatids, and the fourth is common in grebes, muskrats and beaver. Those identified only to genus all belong to genera widespread in aquatic birds. It is interesting that five of the nine cestodes and three of the four acanthocephalans (including _Polymorphus_ spp., most numerous of all helminths) were inhibited.

The two nematodes, _Echinuria uncinata_ and _Streptocara_ sp., were found in the tissues and may well have been inhibited by host immune reactions. Many of the cestode species and most of the _Polymorphus_ spp., _P. paradoxus_ and _Corynosoma ?constrictum_ showed little or no growth or development although occasionally the acanthocephala become fairly well developed. Little host reaction to these latter parasites was evident and I presume that their development was arrested because their nutritional requirements were not satisfied.

It thus appears probable that the majority of inhibited parasites of the coot are those which the coot is ecologically exposed to in high numbers but for which the coot does not fulfill the nutritional requirements for development to maturity.

Orchipedum tracheicola, for which the coot is an inhibitory-auxiliary host, has been found maturing in several anatids and in Bonaparte gulls (University of Alberta collections), and inhibited in grebes.

From the above table and discussion I feel that it is

evident that the coot is the main host for a group of helminths which are narrowly specific to a few ecologically and phylogenetically related hosts, namely, certain Rallidae. This group makes up only 39% of the helminth species recovered. For another 14% of the helminth species, largely non-specific forms, the coot is an auxiliary host. It is probable that only these two groups of helminths reproduce sufficiently in the coot to make a significant contribution to the maintenance of their species. The other 47% of the helminth species, for which the coot is an accidental or inhibitory host, make very little or no contribution to their species gene pools. Of the latter, Polymorphus paradoxus, Lateriporus sp., and Orchipedum tracheicola are relatively common and Polymorphus spp. is the most abundant of all of the helminths recovered in this study. Therefore, one could say that the coot is more affected by parasites carried by other host species ecologically associated with it than its parasites affect them.

Table VII. Specificity of helminths of the coot.

Species	Host type	Species hosts (natural)[1]	Genus hosts (natural)[1]
Trematoda			
Cotylurus hebraicus	main?	*Fulica*	Gaviidae, Anatidae, Rallidae, Charadriiformes
Cyclocoelum mutabile	main	*Fulica*, *Gallinula*, *Porphyrula*, *Jacana*, *Tringa*, *Vanellus*	Mainly Anseriformes, Gruiformes, Charadriiformes, but representive hosts in all water birds and few non-water bird types
C. oculeum	main	*Fulica*, *Gallinula*, *Porzana*	
Neoleucochloridium problematicum	main	*Fulica*, *Gallinula*, *Porzana*, *Gallus* (Exp.?)	Anseriformes, Galliformes, Gruiformes, Charadriiformes, Coraciiformes
Echinostoma attenuatum	main	*Rallus*, *Fulica*	
Echinostoma chloropodis	aux.	*Gallinula*, *Porzana*, *Ortygometra*, *Fulica*, *Calidus*, *Capella*	
Echinostoma revolutum	acc.	Wide range of birds and aquatic mammals.	Wide range of birds and mammals
Echinostoma sp.	acc.	*Fulica*[2]	
Hypoderaeum conoideum	acc.	Anatidae, *Gallus* (Exp.?) *Fulica*, *Columba*, Podicipedidae	Podicipedidae, Anatidae, Phasianidae, Rallidae, Charadriidae, Columbidae
Protechinostoma mucronisertulatum	inhib.	*Porzana*, *Fulica*	Rallidae

cont'd

Table VII. cont'd.

Species	Host type	Species hosts (natural)[1]	Genus hosts (natural)[1]
Ribeiroia thomasi	acc.	Wide number of birds	Podicipediformes, Ciconiiformes, Falconiformes, Gruiformes, Coraciiformes
Notocotylus pacifera	main	_Fulica_, _Gallinula_	Mainly Anatidae, Rallidae, Charadriiformes
Tanasia atra	main	_Fulica_, _Plegadis_ (?) _Motacilla_ (?)	Podicipediformes, Ciconiiformes, Anseriformes, Galliformes, Gruiformes, Charadriiformes, Columbiformes, Piciformes, Passeriformes
Orchipedum tracheicola	aux.-inhib.	_Anas_, _Oidemia_, _Cygnus_, _Tadorna_, _Larus_, _Fulica_, _Podiceps_	Podicipedidae, Pelecanidae, Threskiornithidae, Anatidae, Gruiformes, Charadriiformes
Cestoda			
Schistocephalus solidus	aux.	Wide variety of fish-eating birds and mammals	Wide range of birds and mammals
Diorchis americana	main	_Fulica_, _Gallinula_, _Dendrocitta_, _Gallus_	Podicipedidae Anatidae Rallidae
Diorchis ransomi	main	_Fulica_, _Gallinula_, _Nyroca_, _Aythya_	
Aploparaksis furcigera	acc.	_Anser_, _Anas_, _Dafila_, _Netta_, _Nettion_, _Nyroca_, _Fulica_	Anatidae, Galliformes, Rallidae, Charadriididae, Passeriformes

cont'd

Table VII. cont'd.

Species	Host type	Species hosts (natural)[1]	Genus hosts (natural)[1]
Cloacataenia megalops	inhib.	Wide number of Anatidae, Fulica	Anatidae, Rallidae
Lateriporus A	inhib.	Fulica[2]	Podicipedidae, Anatidae, Charadriiformes, Coraciiformes
Lateriporus B	inhib.	Fulica[2], Podiceps[3]	
Cestoda A	inhib.	Fulica	
Cestoda B	inhib.	Fulica	
Nematoda			
Strongyloides avium	aux.?	Gallus, Junco, Fulica, Anas	Ciconiiformes, Anatidae, Galliformes, Rallidae, Charadriiformes, also in reptiles and mammals
Capillaria fulicae	main	Fulica	Represented in all vertebrate classes
Amidostomum fulicae	main	Fulica, Porzana, Nyroca	Anatidae, Phasianidae, Rallidae, Charadriidae
Echinuria heterobrachiata	acc.	Larus, Fulica	Podicipedidae, Ciconiiformes, Anatidae, Charadriiformes
Echinuria ?uncinata	inhib.	Anatidae, Fulica[2], Philomachus	
Tropisurus sp.	main	Fulica[2]	Wide variety of water and land birds
Streptocara sp.	inhib.	Fulica[2]	Podicipedidae, Ciconiiformes Anatidae, Galliformes, Charadriiformes

cont'd

Table VII. cont'd.

Species	Host type	Species hosts (natural)[1]	Genus hosts (natural)[1]
Spirofilaria fulicaeatrae	main	*Fulica*, *Podiceps*	Podicipedidae, Rallidae
Acanthocephala			
Polymorphus trochus	main	*Fulica*, *Anas*	Podicipedidae, Ciconiiformes, Anatidae, Rallidae, Charadriiformes, mammals
Polymorphus paradoxus	inhib.	*Podiceps*, *Aechmophorus*, *Fulica* Mammals: *Castor*, *Ondatra*	
Polymorphus spp.	inhib.	*Fulica*[2]	
Corynosoma ?constrictum	inhib.	*Anas*, *Aythya*, *Bucephala*, *Melanitta*, *Oxyura*, *Fulica*	Podicipedidae, Pelecaniformes, Ciconiiformes, Anatidae, marine and aquatic mammals
Hirudinea			
Theromyzon rude	aux.	*Anas*, *Spatula*, *Oxyura*, *Aythya*, *Fulica*	Podicipedidae, Ardeidae, Anatidae, Rallidae, Charadriiformes

Foot Notes:

[1]from hosts listed by Yamaguti (1958, 1959, 1961, 1963)

[2]present work

[3]Gallimore (1964)

INFLUENCE OF HOST FACTORS

Host Sex

To determine if female and male birds could be combined in order to show general trends in the helminthofauna, the data were analyzed for differences due to sex of host. The mean total helminth burden of adult females was 54.2 worms; that of adult males 63.2 worms. The mean total helminth burden of immature females was 74.7; of immature males 90.1 worms. A Chi-square test showed no significant difference from a 1:1 ratio; Chi-square for adults was .61; for immatures, 1.43 with 1 degree of freedom.

Although the differences in total helminth load of the adult male and female coots was not significant, the slight difference was a rather constant factor, with adult males being more heavily infected in 8 of 11 sampling periods; no such pattern appeared in the immatures.

The lack of a significant difference would be expected from knowledge of coot biology (summarized by Gullion, 1954). Male and female coots appear to have similar behavior throughout the breeding period; both adults build the nest, incubate the eggs and brood the young. Thus they are always closely associated, in the same habitat, and are presumably under similar physiological stresses.

Adult males are somewhat larger, however, and presumably eat slightly more than females. This may explain the slight but consistent difference in total helminth load between adult males and females. A similar difference in the number of

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Notocotylus attenuatus correlated with host size was observed by Schad (1962).

The effect of host sex on the numbers of individual species of helminths was not analyzed statistically; however, no consistent effects appeared to exist. Therefore, the sexes have been combined in all subsequent analyses.

Host Age

The data were also analyzed for the effects of age of the coot on its helminthofauna. Immatures were aged by plumage characters, coloration of soft parts and size as outlined by Gullion (1954). These methods were not entirely satisfactory as birds aged in this way appeared to be older than the few observations on hatching dates would indicate. However, no better method was available so these methods were used for the present study. The adults and immatures could be distinguished at all times by plumage, leg color and bill characters. Methods of aging the adults (to 1,2, and 3 year old classes) were given by Gullion (1952b) but these proved difficult to apply and were not used here.

There are 7 species of helminths that occur only in the adults and 6 species that occur only in the immatures (Table II). Eleven of the 13 species occurring in only one age group belong to those helminths where the coot is an inhibitory or accidental host and occur only in low extensity; the slight chance of finding them probably accounts for their occurrence in only one age class. Two of the species occurring only in adults have the coot as the main host; these may be southern helminths or,

particularly in the case of Spirofilaria fulicaeatrae, may have a long developmental period precluding the finding of it in the immatures.

A comparison of the extensity and intensity data suggests that they reflect somewhat different influences. The extensity appears to illustrate the availability of infective stages, whereas the intensity appears to show, in addition, the effect of the internal environment. Two lines of evidence support this suggestion. First, in 14 of the 16 species shown in Figure 21, the intensity of infection in the immatures is equal to or greater than that in the adults regardless of extensity, suggesting a lower resistance to infection on the part of the immatures. Second, there is a sudden decline in the overall intensity of trematode infections in young coots in late July (see Annual Variation); at the same time, the extensity of trematode infections increased. The reason for this decline in intensity of infection among growing birds may be an increasing resistance to helminthic infection, possibly brought about by naturally acquired immunization.

From the comparison of the extensity of main groups of helminths in adults and immatures (Fig. 21), it is evident that the trematodes and perhaps cestodes are highest in the immatures, while nematodes are highest in adults. Acanthocephala have a similar extensity in both ages but a higher intensity in immatures. Leeches have a much higher extensity in immatures but intensities are essentially the same. The extensity of all helminths combined is 100% in adults and only slightly less in the immatures (due largely to a few very

Figure 21

Relative infections of adult and immature coots.

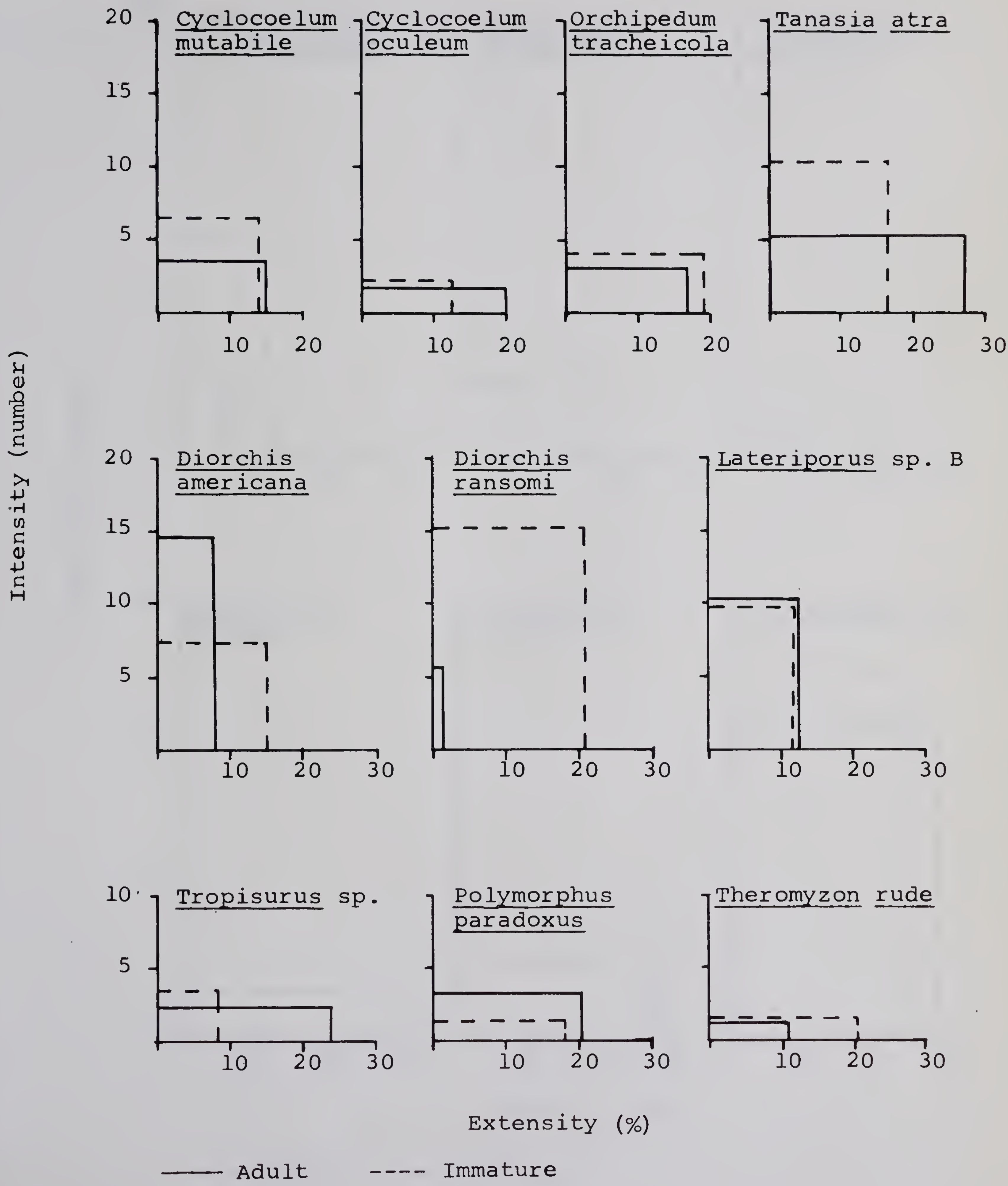


Figure 21 (cont'd).

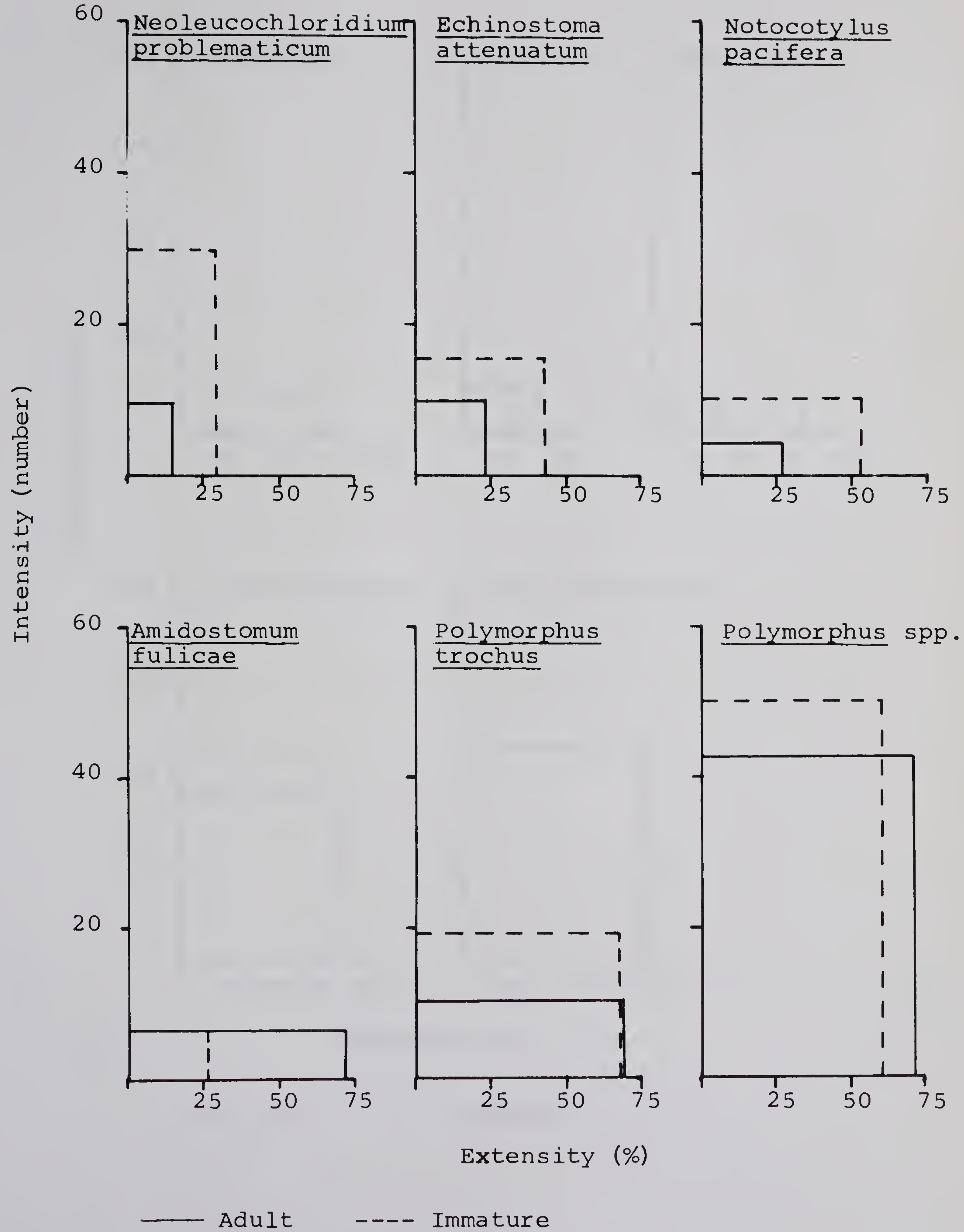
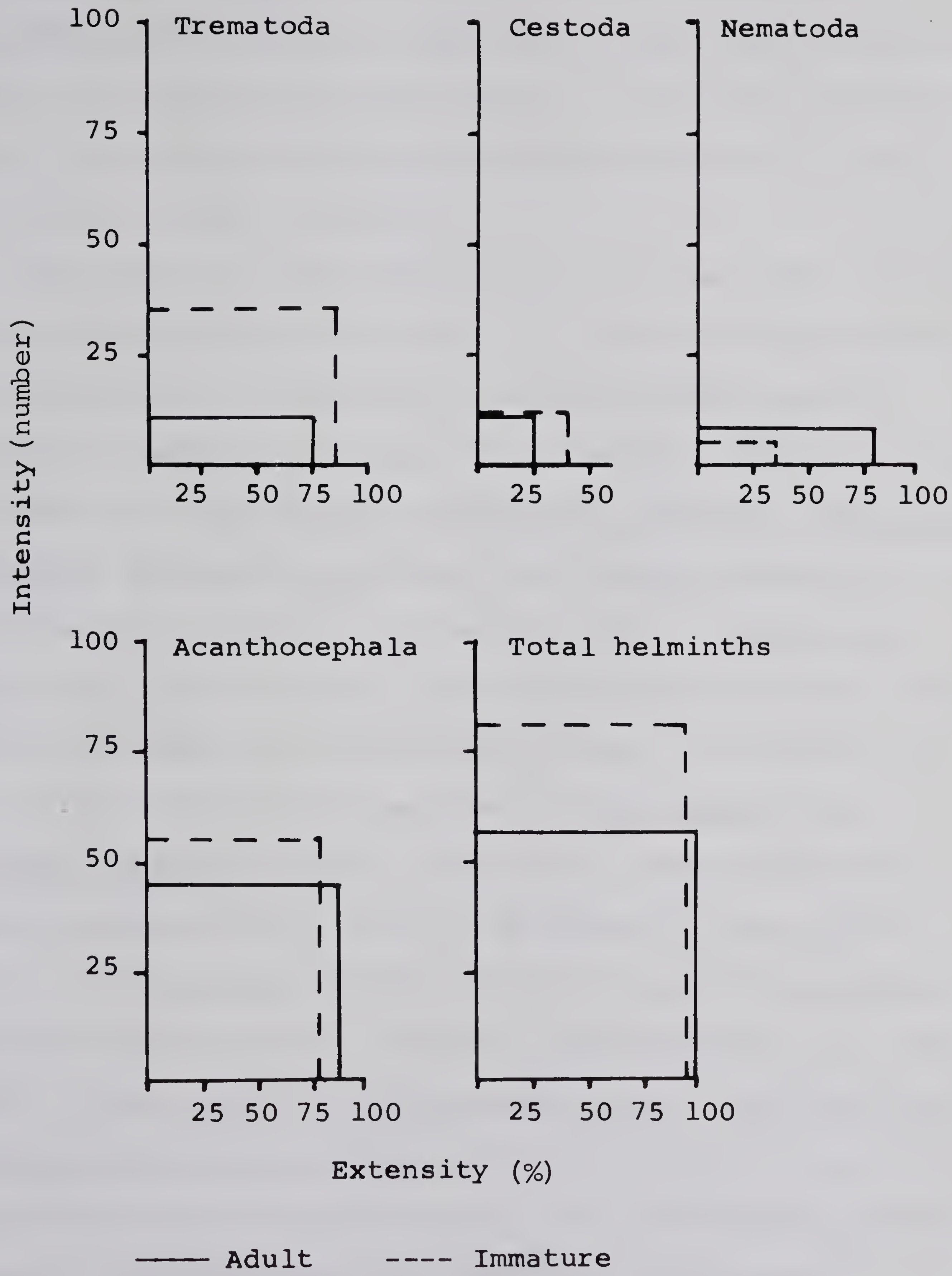


Figure 21 (cont'd).



young birds not yet infected). The intensity is substantially higher in the immatures due to the higher intensity of trematodes and acanthocephala in immatures. The higher infection in immatures than adults is in agreement with Bychovskaya-Pavlovskaya (1962), Cornwell and Cowan (1963) and Ginetsinskaya (1952) for a variety of water birds; in contrast, Gallimore (1964) found little difference between infections in adult and immature grebes in Alberta.

Many species in the above groups are consistent with the relationship shown by the groups. In Figure 21 the extensities and intensities of infections of sixteen common species occurring in adults and immatures are shown. From this figure it is seen that Neoleucochloridium problematicum, Echinostoma attenuatum, Notocotylus pacifera and Diorchis ransomi are predominantely parasites of immature coots. Polymorphus trochus was found in almost equal extensities in both, but the intensity in immatures was markedly higher. A similar but less distinct difference was shown by Polymorphus spp. Theromyzon rude has higher extensity in immatures but the intensities are similar in both age classes. Thus these species follow group patterns and tend to give the patterns illustrated by trematode, cestode, acanthocephalan and leech groups. Tropisurus sp., Amidostomum fulicae, Capillaria fulicae and Spirofilaria fulicaeatrae (last two found only in adults therefore not shown in the figure) are predominately parasites of adults and thus agree with nematodes as a group.

Species that do not conform to the typical patterns of their group are illustrated by four trematodes, two cestodes and

an acanthocephalan. The trematodes Cyclocoelum mutabile, C. oculeum, Tanasia atra and Orchipedum tracheicola generally have similar to slightly lower extensity with slightly higher intensity in the immatures as compared to the adults. The cestode Diorchis americana has a lower extensity in adults but higher intensity. Lateriporus sp. B and the acanthocephalan Polymorphus paradoxus show little difference.

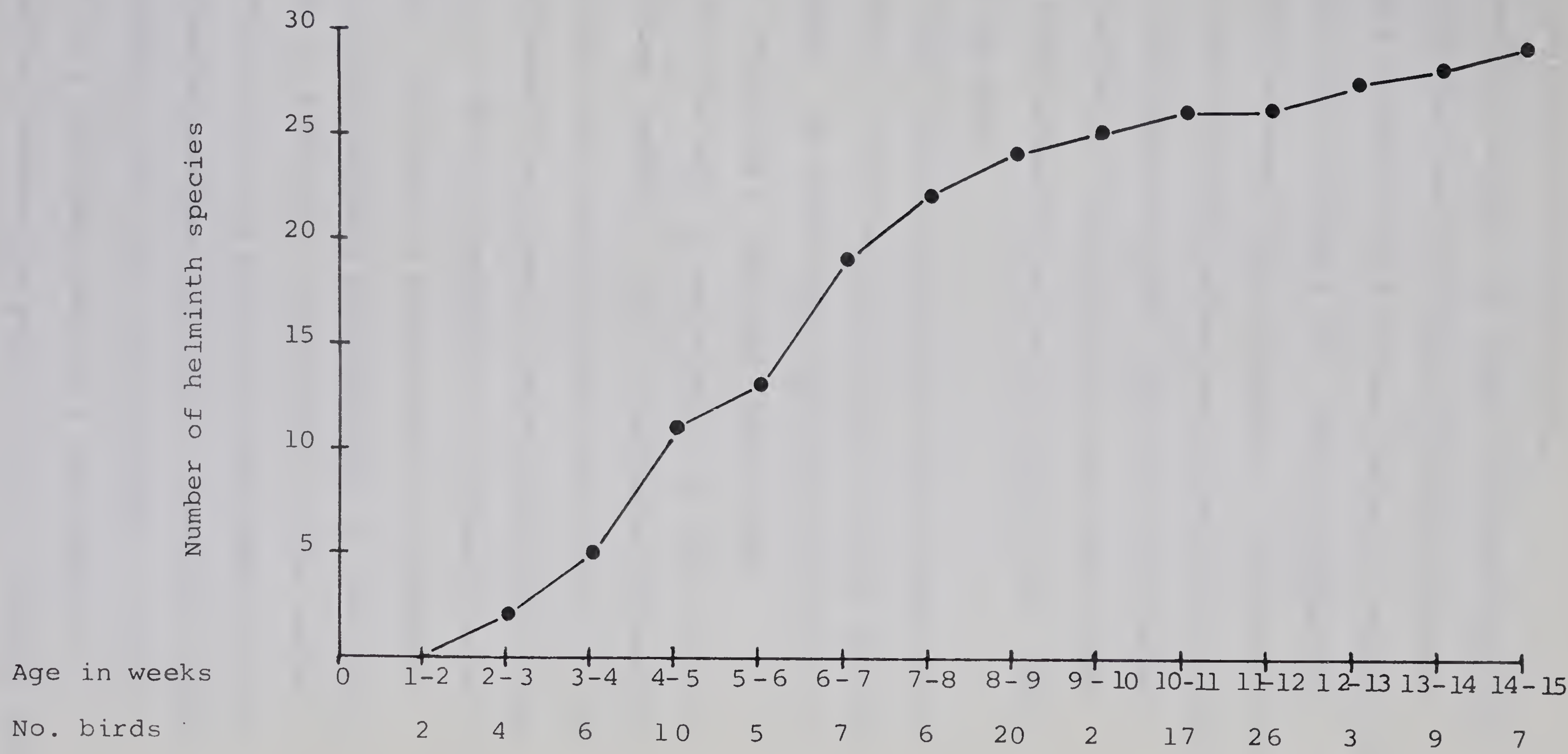
Only five and perhaps six of the parasites for which the coot is a main host predominate in immature coots as illustrated in Figure 21; two others do not appear in immature coots. Polymorphus spp. is also the most abundant parasite found in immatures but does not mature. This disagrees with Ginetsinskaya (1952) who stated that, for the European coot (Fulica atra), in the Volga Delta, the specific parasites predominate in the young coots.

In this study, adults carried 11 species of trematodes and the immatures 13. Of the total number of helminths, 30 species were in adults and 29 in immatures (Table II). These results disagree with Bychovskaya-Pavlovskaya's (1962) generality that adults have a more diverse trematode fauna than immatures; neither is the overall diversity of helminths greater in adult coots.

The acquisition of the helminths by age is illustrated in Figure 22. Young coots appear to acquire their helminths slowly, with the majority of the species first encountered in their second month of life. The fact that coots are infected with only two helminths in first 2-3 weeks agrees with Ginetsinkaya (1952) who found that in the first two weeks

Figure 22

Acquisition of helminths with age of immature coots.



Fulica atra was quite free of endoparasites.

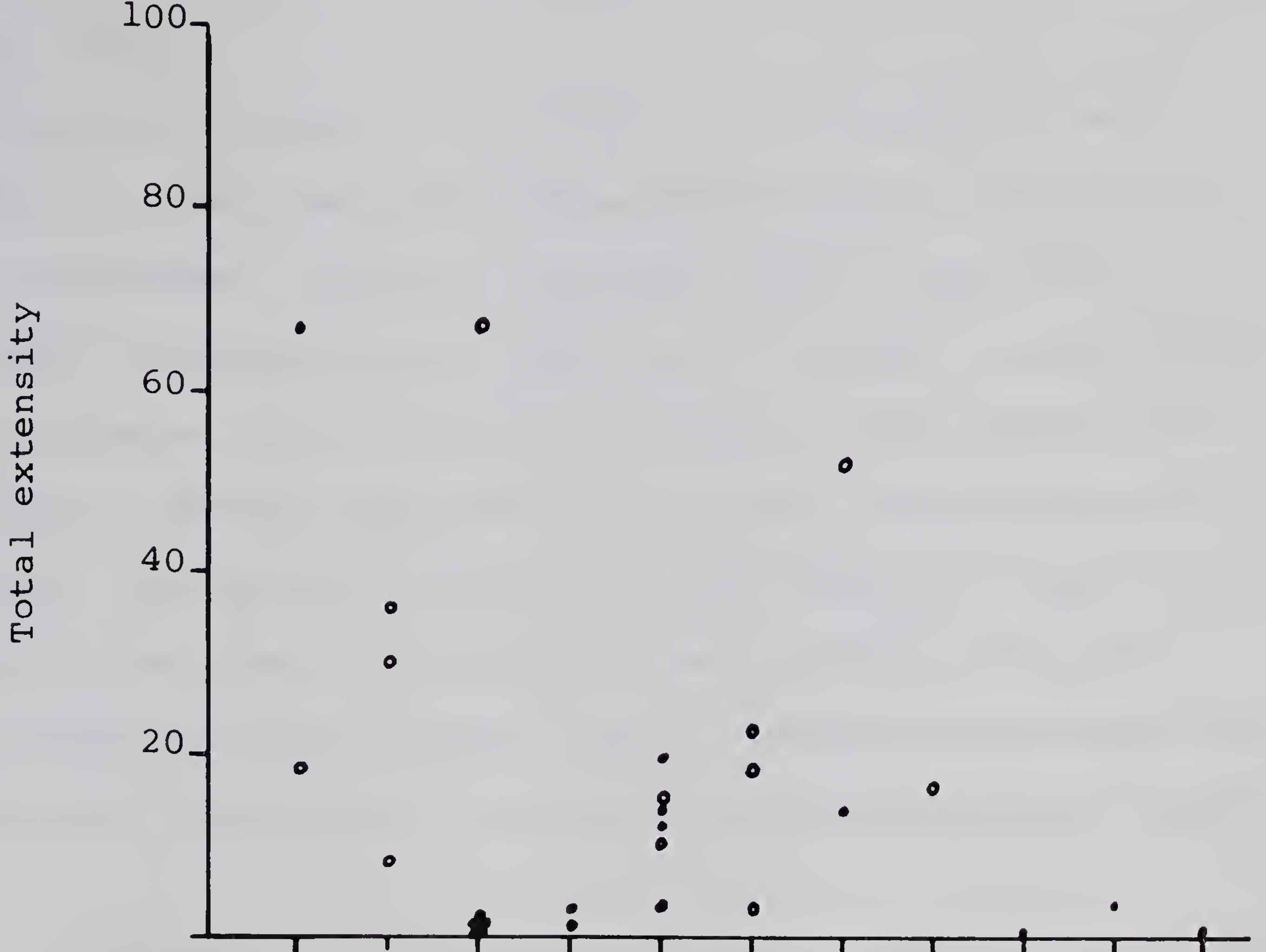
The relationships between the order of acquisition (as indicated by age of the host) of helminths and commonness (measured by total extensity) and between order of acquisition and host type are shown in Figure 23. There is apparently little relationship between these variables. If Ginetsinskaya's (1952) statement that specific parasites predominate in young coots is correct for American coots, then one would expect those helminths for which the coot is the main host to be correlated with high extensity and early acquisition. This was not found to be true.

Gallimore (1964) found a relatively higher correlation between these factors in the helminth fauna of three species of grebes in Alberta. He found that the first helminths to be acquired were, in general, the more common ones.

The reason for the lack of correlation in this study is probably due to three factors. One is the change of feeding habitats of the young coots as they grow older; that is, they move from inshore areas when young to more open water as they age. Thus there is a shift in exposure to different infective stages in different intermediate hosts with the different habitat (e.g. *Neoleucochloridium problematicum* in land snails on shore, cestodes in planktonic crustaceans in open water). A second factor would be a long period of development of the larvae of some parasite species; the lack of infective stages could prevent the young coots from being infected. A third factor, operative in a few cases, may be a long period of development in the coot before the parasite can be readily found.

Figure 23

Relationships between the order of acquisition, commonness, and host type of the helminths of immature coots.



Age of host in weeks	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
Trematode	(1)	(2)	3		(1)	(2)	1	(1)		1	1
Cestode		(1)	1		(1) 2				1		
Nematode			1	1		(1)	(1)			1	
Acantho-cephala	1		(1)	1	1						
Leech					1						

◦ and ( ) species with coot as main host

• coot not main host

Thus, parasites that undergo tissue migration may not appear for some period after infection. This may be the reason that the cyclocoelids did not appear until relatively late, as they are known to have a tissue migration (Ginetsinskaya and Saakova, 1952).

The general order of infection in this study as seen in Figure 23 is trematodes and acanthocephala, cestodes and lastly nematodes. Cornwell and Cowan (1963) found that trematodes and cestodes were the first to appear in canvasback ducks. However, Bychovskaya-Pavlovskaya (1962) states that for birds in general the order is cestodes, acanthocephalans, nematodes, and lastly, trematodes, which does not agree with either of the above. The inshore feeding habits of young coots probably account for the early infection with trematodes as the snail intermediate is readily available in this habitat zone.

It is evident that differences between immatures and adults do exist; thus, the two age classes are separated in subsequent analyses.

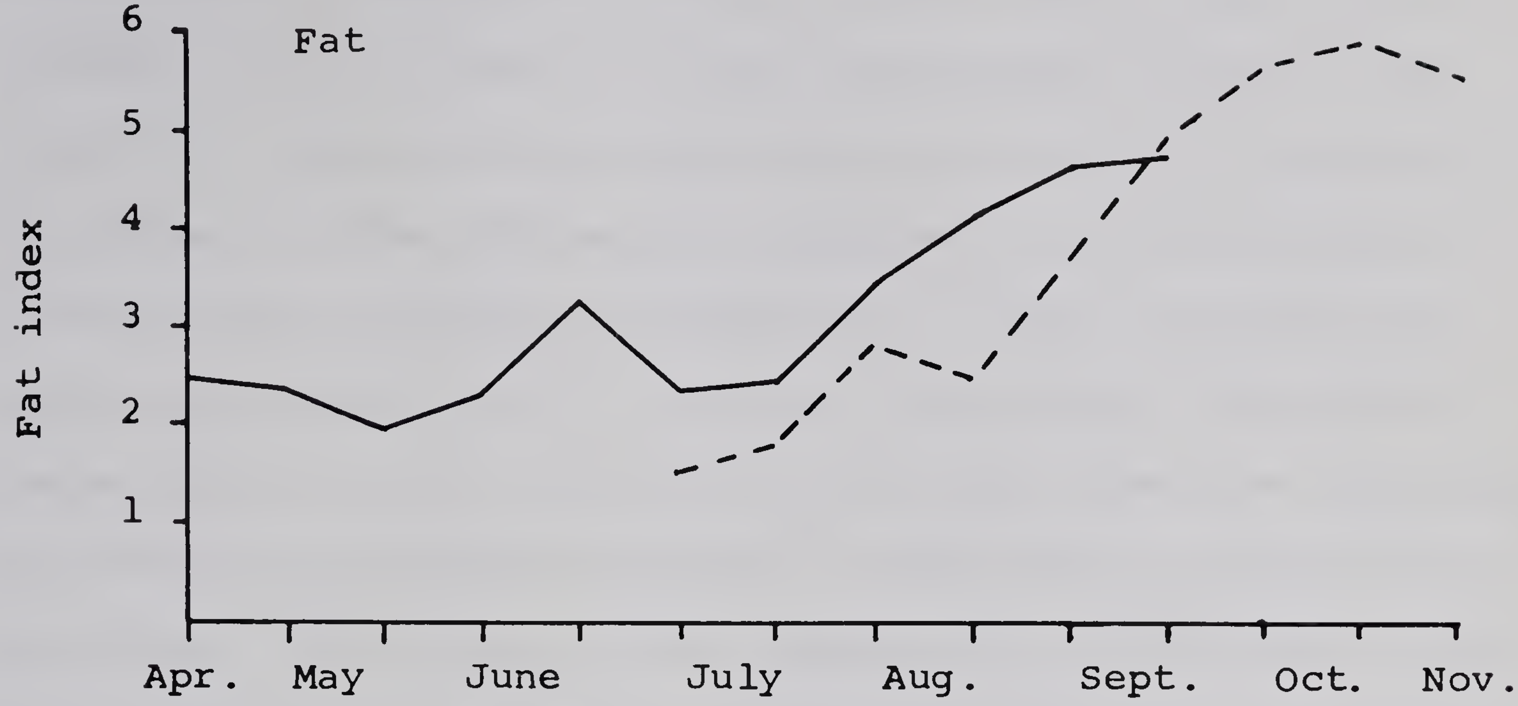
Host Condition

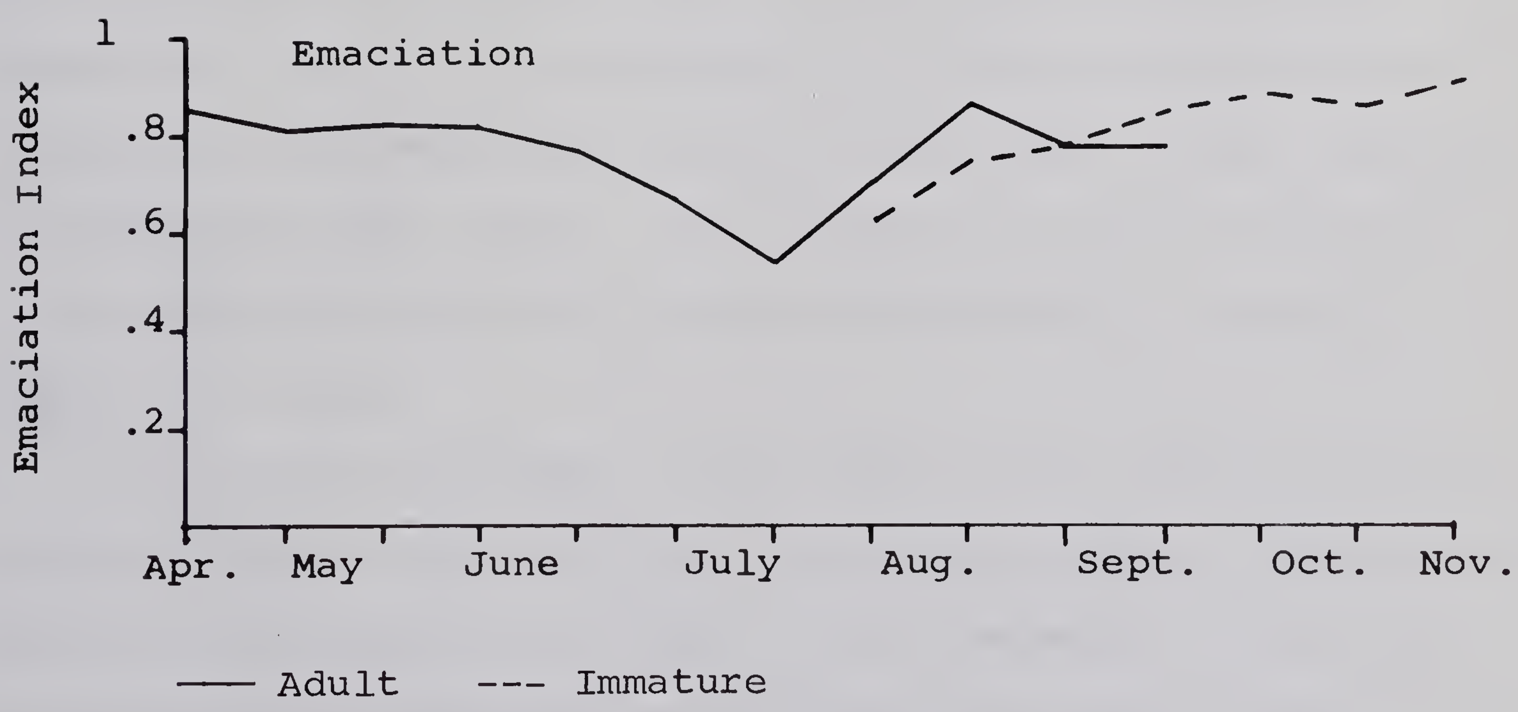
Two indices of host condition, a fat index and the Emaciation Index (E.I.) proposed by Cornwell and Cowan (1963), were taken during autopsy.

The relative amount of fat was rated on a numerical scale from 1 (only a trace of fat present) to 6 (a thick layer of fat under the skin and surrounding all the organs). This index showed a definite seasonal variation (Fig. 24). Such seasonal

Figure 24

Seasonal variations in condition indices of coots collected in this study.





changes in fat components of migratory birds are well known (King, 1963; Odum et al., 1964), and are apparently unrelated to the general health of the birds. However, such changes may reflect influences on the helminth fauna. King (1963) brought out that there is strong experimental evidence that vernal fat deposition in white-crowned sparrows is controlled by changes in the photoperiod and depends calorically upon a stimulation of appetite (hyperphagia). This same mechanism also occurs in the fall, but with a less marked onset of fat deposition. If this is also true in coots, then the hyperphagia may result in increased exposure of the bird to infection by parasites. Odum et al. (1964) suggest that, especially in the small passerines they were studying, the fat is then used in migration as a fuel with little use of other tissues and no feeding. If in coots the fat is also used as the most important source of fuel and little feeding is done during migration the following may occur: (1) a reduction of exposure to helminths, and (2) the elimination of at least some of the intestinal helminths due to reduced nutrients in the intestine (reviewed by Read, 1959). The factors mentioned above could cause seasonal influences on the helminthofauna which will be dealt with later.

The Emaciation Index is the ratio of the depth of breast muscle, measured one inch from the anterior edge of the sternum and one centimeter to the right, over the depth of the keel of the sternum, measured one inch from the anterior edge, as described by Cornwell and Cowan (1963). This ratio also shows a seasonal variation (Fig. 24). This is caused by the degeneration

of breast muscle due to the cessation of flying from the nesting period until the end of molt. The increase of this index in the late summer may indicate an increase in metabolism (and the amount of food ingested) due to the energy demands for regeneration of breast muscle for flight.

Thus, the two indices of condition used in this study are more indicative of the normal anatomical changes which are due to metabolic changes due in turn to seasonal factors in the coots' ecology rather than of the health of the individual bird. Extremely low values of either index may indicate poor health; however, only one such value was found in this survey, in an adult with an enlarged bursa (see pathology section). The poor health of this individual was due to mechanical blockage of the gut and was apparently unrelated to its helminth burden. No overall correlation between either index and the number of total helminths or the number of any individual species was found.

INFLUENCE OF ENVIRONMENTAL FACTORS

Annual Variation

Annual variation in the parasite fauna of various groups of vertebrates has been reviewed by Dogiel (1963); other examples are given from Polish studies of the parasites of vertebrates in several papers in Acta Parasitologica Polonica, for trematodes of birds of U.S.S.R. by Bychovskaya-Pavloskaya (1962), for the helminths of canvasback ducks by Cornwell and Cowan (1963) and for helminths of grebes by Gallimore (1964).

The coot population in Alberta is not constant (Smith, 1956) but reflects the availability of nesting habitats due to differences in climatic factors and the effects of agricultural practices. In 1963 there were abundant nesting areas in the marshy areas of the lakes and in the many small sloughs available to coots; however, due to the drought of that year and the poor runoff in the spring of 1964, most of these areas were not available during the 1964 breeding season. Water levels in many of the large shallow lakes (e.g. Cooking Lake, Big Island Lake, and Cawes Lake) in the area dropped to such an extent that much of the emergent vegetation required by coots was left on dry land. Hastings Lake was an exception, probably due to maintenance of its water level by an underground source. Sloughs, including the one 2-1/2 miles south of Josephburg, were dry or almost dry, so that no coots nested on them in 1964.

As a result, there was a major shift of the coot population off the sloughs and onto the larger lakes. The samples of birds collected reflected this shift, as can be seen in Table I.

Because of the habitat shift, the ecological effects of the prolonged dry period, the cooler summer of 1964 (Kerekes, 1965), and the extent of the annual variations reported previously, it is evident that such variation should be expected in the present study.

The 1963 and 1964 seasons were compared by taking a period from April 15 to May 31 to indicate the spring fauna of adults and a period from July 15 to September 15 to indicate the summer infections in adults and immatures. Only the major species were used for comparison of the two seasons (Table VIII). The spring period samples included parasites brought in from the wintering grounds as well as parasites obtained locally. The summer period collections included birds that were collecting in flocks (after September 1), but they were still believed to be local birds.

From Table VIII it is evident that the total infections in the spring period of the two years were very similar, with only a relatively slight increase in 1964. This increase was due to a marked increase in the extensity and intensity of acanthocephala which in turn is probably due to the difference in habitat (the 1963 sample came from sloughs, while the 1964 sample came from Cooking and Hastings Lakes; see the section on habitats).

Most of the common species showed some difference in infection rates between the two spring periods; some of them showed significant changes in extensity and/or intensity of infection. The habitat difference mentioned above probably accounts for the increase of *Polymorphus* spp., *P. trochus* and

Table VIII. Annual variation in the major helminths of coots.

	Dates	April 15 - May 31				July 16 - September 15			
	Year	1963		1964		1963		1964	
	No. of Adults	30		47		29		41	
	No. of Immatures					41		39	
	Host age	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
<u>Cyclocoelum</u> <u>mutabile</u>	Adults	50	1.9	47	2.0	3	2.0	7	4.3
	Imm.					2	1.0	23	3.2
<u>C. oculeum</u>	Adults	17	3.6	28	4.5	3	1.0	10	2.3
	Imm.							5	1.5
<u>Neoleucochloridium problematicum</u>	Adults	10	10.0	2	4.0	38	5.6	5	3.5
	Imm.					54	30.4	23	17.4
<u>Echinostoma</u> <u>attenuatum</u>	Adults	33	12.0	19	11.0	24	2.7	29	4.8
	Imm.					44	17.2	54	7.2
<u>Notocotylus</u> <u>pacifera</u>	Adults	10	7.7	15	5.3	52	7.0	32	4.6
	Imm.					49	11.7	56	7.8
<u>Tanasia</u> <u>atra</u>	Adults	27	2.3	36	4.7	14	4.6	27	6.5
	Imm.					7	5.3	13	11.0
<u>Diorchis</u> <u>americana</u>	Adults	7	28.0	4	3.0			24	14.4
	Imm.					32	7.5	18	9.6
<u>D. ransomi</u>	Adults	3	3.0					2	4.0
	Imm.					24	23.2	18	18.9
<u>Lateriporus</u> sp. B	Adults	10	18.0	26	6.8	7	3.0		
	Imm.					5	1.0	5	5.0
<u>Amidostomum</u> <u>fulicae</u>	Adults	100*	7.9*	96	8.6	31	4.8	37	2.5
	Imm.					12	4.0	38	3.6

cont'd

Table VIII. cont'd.

	Dates	April 15 - May 31				July 16 - September 15			
	Year	1963		1964		1963		1964	
	No. of Adults	30		47		29		41	
	No. of Immatures					41		39	
	Host age	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
Tropisurus sp.	Adults	23	2.1	17	3.8	17	2.0	17	2.0
	Imm.					5	1.0	10	1.0
Polymorphus trochus	Adults	43	4.2	72	12.8	79	11.5	83	9.3
	Imm.					61	17.8	85	18.2
P. paradoxus	Adults	43	4.9	17	2.8	28	1.5	17	3.3
	Imm.					17	2.3	25	2.3
Polymorphus spp.	Adults	70	37.1	98	64.4	49	33.3	54	13.6
	Imm.					46	67.1	74	18.3
Theromyzon rude	Adults	16	1.4	4	1.5	10	1.7	22	1.3
	Imm.					37	1.5	23	2.4
Trematodes	Adults	80	10.9	85	9.7	83	6.3	68	8.6
	Imm.					90	36.7	95	17.4
Cestodes	Adults	29	16.9	34	16.4	21	2.2	29	12.4
	Imm.					54	17.8	39	14.1
Nematodes	Adults	100*	16.0*	98	10.4	48	4.9	85	4.2
	Imm.					18	3.1	41	3.7
Acanthocephala	Adults	87	34.8	100	72.6	93	34.9	93	16.7
	Imm.					68	59.5	100	29.7
Total Helminths	Adults	100	71.6	100	93.4	100	40.5	100	28.1
	Imm.					100	83.8	100	53.2

* only 9 birds in 1963

Lateriporus sp. B, all of which are carried by gammarids, which are in low numbers in sloughs compared to the other habitats. An exception is Polymorphus paradoxus.

The same habitat difference may account for the absence in 1964 of Diorchis ransomi, which appears to be more common in sloughs. The other differences are not as easily explained, and may represent differences in helminths brought from the wintering grounds and/or differences due to the relative dryness of 1964.

The summer differences were more marked than the spring ones; extensive differences in the extensity and/or intensity of infection were found in each of the major groups of helminths. The total intensity of infection dropped in 1964 in both adult and immature coots; the other differences, however, showed no uniform pattern.

The trematodes decreased in extensity in adults and in intensity in immatures in 1964. The marked decrease in the extensity of Neoleucochloridium problematicum and Notocotylus pacifera in adult coots produced an overall decrease despite the increase in extensity of all the other trematode species. No substantial intensity changes occurred in any of the species of trematodes in adults. In the immature coots no significant change occurred in the total trematode extensity but this was due to compensating changes in individual species. Cyclocoelum mutabile increased considerably in extensity and lesser increases were observed in C. oculeum, Notocotylus pacifera, Echinostoma attenuatum, and Tanasia atra but these were offset by a marked drop in Neoleucochloridium problematicum.

The overall intensity drop is the result of large decreases in Neoleucochloridum problematicum and Echinostoma attenuatum and lesser offsetting fluctuations in the other species.

The extensity and intensity of cestodes rose somewhat in the adult coots in 1964. This rise is mainly due to the presence, in significant number, of Diorchis americana in 1964, whereas it was not found in 1963. Cestodes in immature coots showed an opposite trend, with extensity and intensity dropping. The extensity drop is mainly influenced by the drop in both D. americana and D. ransomi; the intensity drop occurred only in D. ransomi, probably due to a lack of samples from sloughs (see Habitat).

The nematodes showed an increase in extensity in both immatures and adults in 1964. The increase in the adults is probably due to inclusion in the 1964 data of Spirofilaria fulicaeatrae, Capillaria fulicae, and Strongyloides avium which were not found in 1963, probably due to faulty techniques. The increase in the immatures is due in addition to an increase in the extensity of Amidostomum fulicae.

The extensity of acanthocephala in the immatures rose, but their intensity dropped in both age groups in 1964. The increase in extensity in immatures is due to increases in both Polymorphus spp. and Polymorphus trochus, while the decrease in intensity in both age classes is due to Polymorphus spp.

The leeches, represented solely by Theromyzon rude, showed a drop in extensity in the spring of 1964. In the summer period, the extensity in adults rose while that in immatures dropped.

The data of the two seasons of 1963 and 1964 do show

definite differences in infection rates. These differences are in part believed to be artifical due to differential sampling of different habitats and/or due to faulty technique in 1963 (for some nematode species). However, I feel that many of the differences are real, due to changes in the environment which favoured or disfavoured individual helminth species.

Seasonal Variation

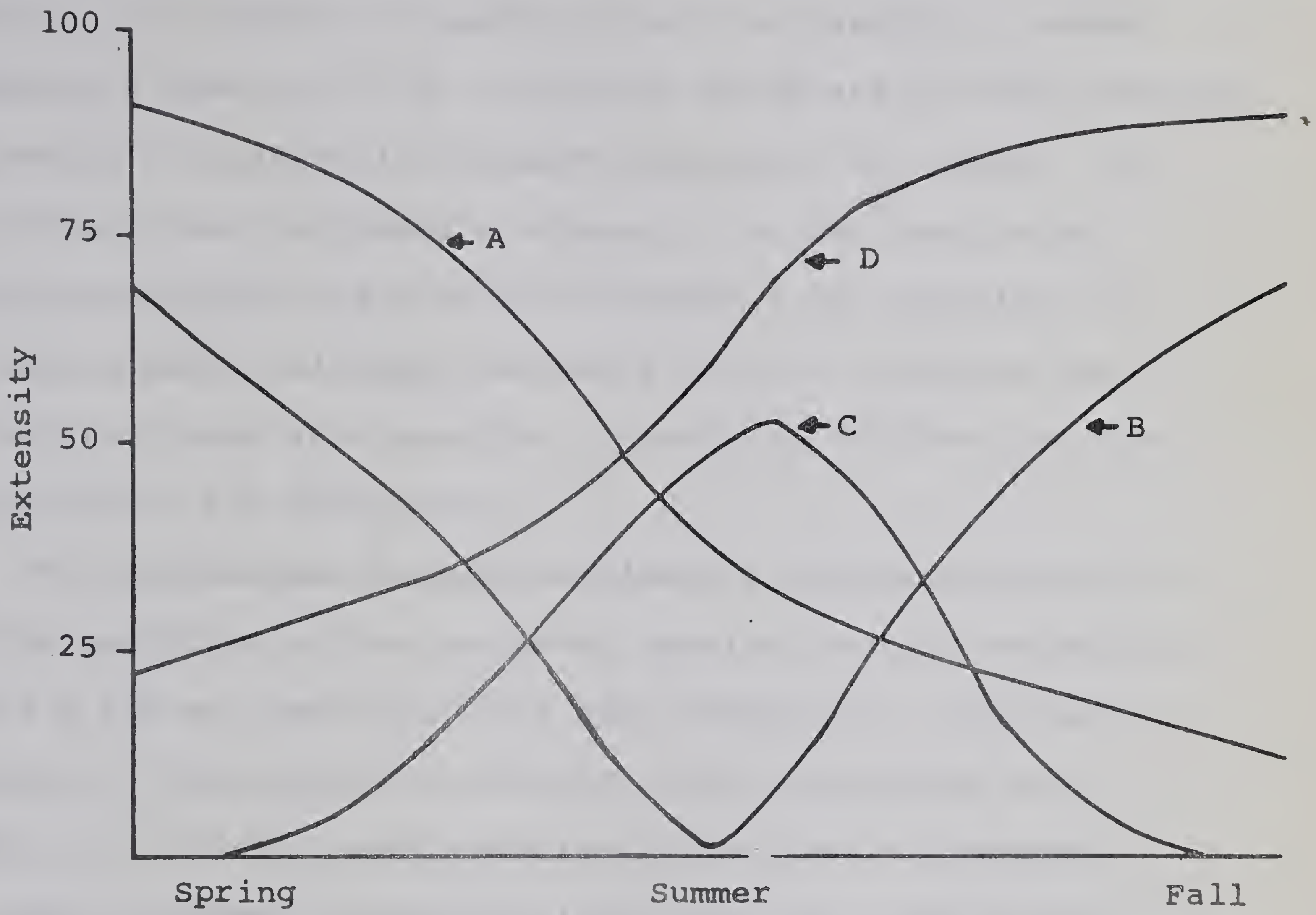
Seasonal changes in the helminthofauna of aquatic birds have been noted by several authors (Ginetsinskaya, 1952; Bezubik, 1956; Czaplinski, 1956; Okorokov, 1957; Bychovskaya-Pavlovskaya, 1962, Sulgostowska, 1963; Gallimore, 1964, inter alia). Because of the relatively large samples of a single host species collected every two weeks in this study, fairly distinct changes in the extensity of the individual major species of helminths could be recognized. Five basic patterns (four of which are illustrated in Figure 25) were recognized:

a) Spring peak: high extensity in spring, dropping through the summer.
b) Spring-fall peak: high extensity in spring and fall with lower extensity in mid-summer.
c) Summer peak: low extensity in spring and fall with higher extensity in summer.
d) Fall peak: gradually increasing extensity reaching a maximum in fall.
e) Irregular: no general trends of infection obvious.

Gallimore (1964) also devised a classification of the patterns of seasonal extensity changes. His classification

Figure 25

Patterns of seasonal variation in extensity of coot helminths.



A - spring peak

B – spring-fall peak

C - summer peak

D - fall peak

was oriented to show the origin of the infections; he used four groups: (1) helminths showing little general trend of infection, (2) helminths not brought in from the wintering grounds but which complete their life cycle locally, (3) helminths found in low numbers in spring, then rose rapidly in summer reaching a peak, and (4) helminths which are of high extensity in spring and gradually decrease throughout the summer. It is obvious that Gallimore's category 1 is the same as my irregular pattern and that his category 4 is equivalent to my spring peak. Although Gallimore did not recognize the spring-fall peak as a specific category he did describe such a pattern in his discussion.

The differences between Gallimore's system and mine lie in the partition of the remaining species into his categories 2 and 3 and my summer and fall peak categories. Gallimore's category 2 (helminths not brought in but completing their life cycle locally) was specifically designed to separate presumed "northern" parasites (parasites transmitted only on the nesting grounds) from the "ubiquists" (parasites of both nesting and wintering grounds - see Bychovskaya-Pavlovskaya (1962) for further discussion of this terminology) of his category 3. A shift in emphasis from the presence or absence of relatively infrequent spring infections to the timing of the major peak of infection was considered to be more useful in this study.

Sixteen species of helminths which occurred with a relatively high extensity in coots were analyzed for seasonal variation. One species showed a spring peak, six had spring-

fall peaks, six had summer peaks, one species a fall peak, and the other two showed irregular fluctuations in abundance.

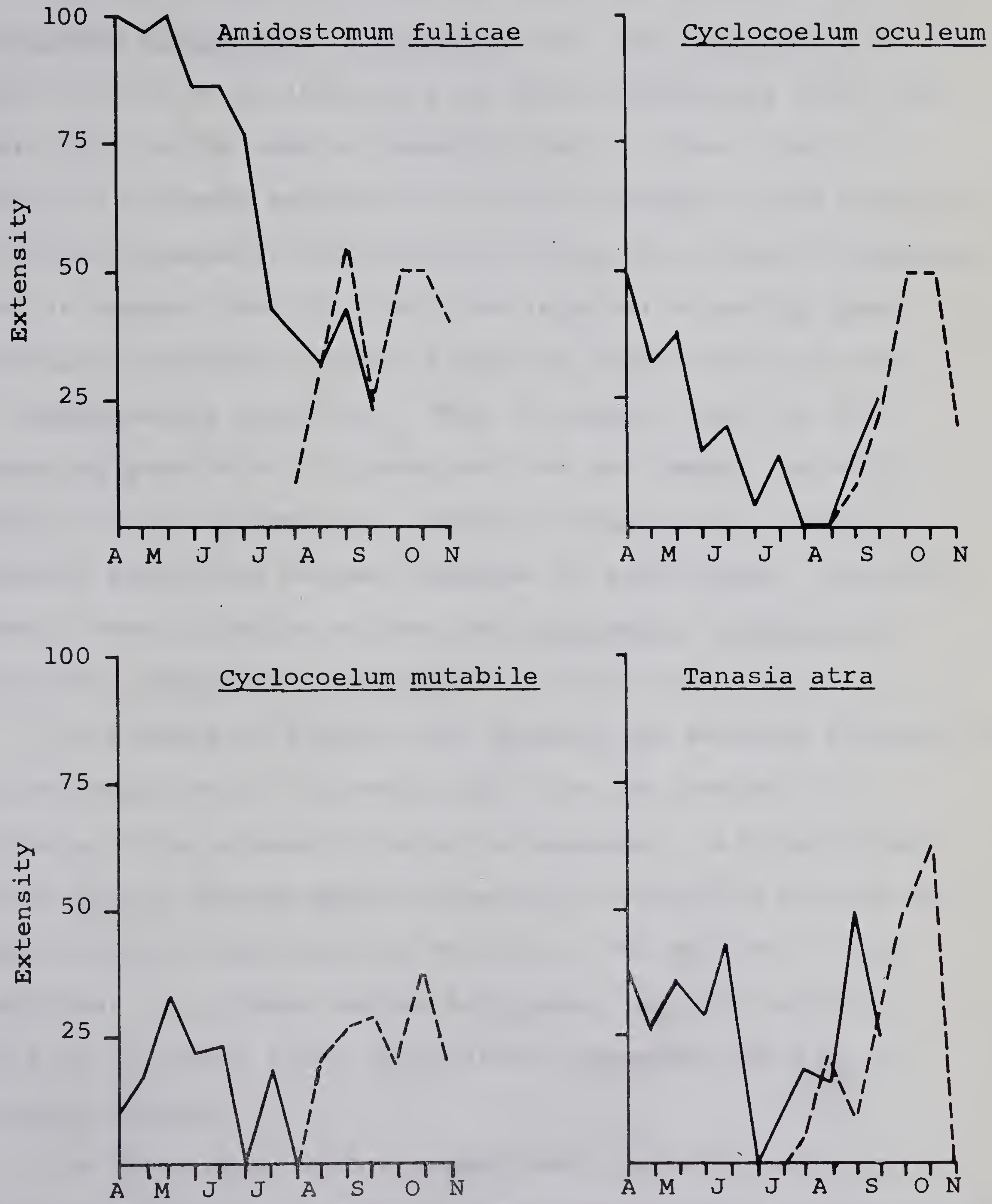
The only parasite with a spring peak was Amidostomum fulicae (Fig. 26) which has an extensity of 100% in spring, dropping to 25-50% after mid-July. Birds infected on the wintering grounds seed the breeding area upon arrival in spring, then apparently lose their infections rapidly. Young coots were first found infected with adult worms in early August, indicating a period of development from egg to adult of some three months under local conditions. This is at least double the expected developmental period (Leiby and Olsen, 1965), even taking into consideration the low water temperatures early in the season, suggesting that some ecological factor hinders rapid acquisition of this parasite by the young coots. The same factor may prevent a peak of infection in the fall. Ginetsinskaya (1952) found the same pattern of seasonal variation in A. raillieti (=A. fulicae) in European coots.

The second type, with spring-fall peaks, is illustrated by six of the major helminths of the coot.

Cyclocoelum oculeum, C. mutabile and Tanasia atra (Fig. 26) are believed to have this type of extensity pattern because of the interaction of two factors, the relatively long period of larval development in the intermediate host (Palmer, 1963) and the loss of the adult worms in early summer. Thus spring birds seed the breeding grounds with eggs and then lose their worm burden before new infections are apparent. The latter may be some time after infection as a tissue migration of some form is apparently required (at least for Cyclocoelum, according to

Figure 26

Seasonal variation in extensity of Amidostomum fulicae, Cyclocoelum oculeum, Cyclocoelum mutabile, and Tanasia atra.



Ticks on the abscissa and points on the graph represent half month collecting periods from April 15 to November 15.

—— Adult --- Immature

Ginetsinskaya and Saakova, 1952) in order for these species to reach their normal location. However, by late fall all three species have reached a second peak of infection.

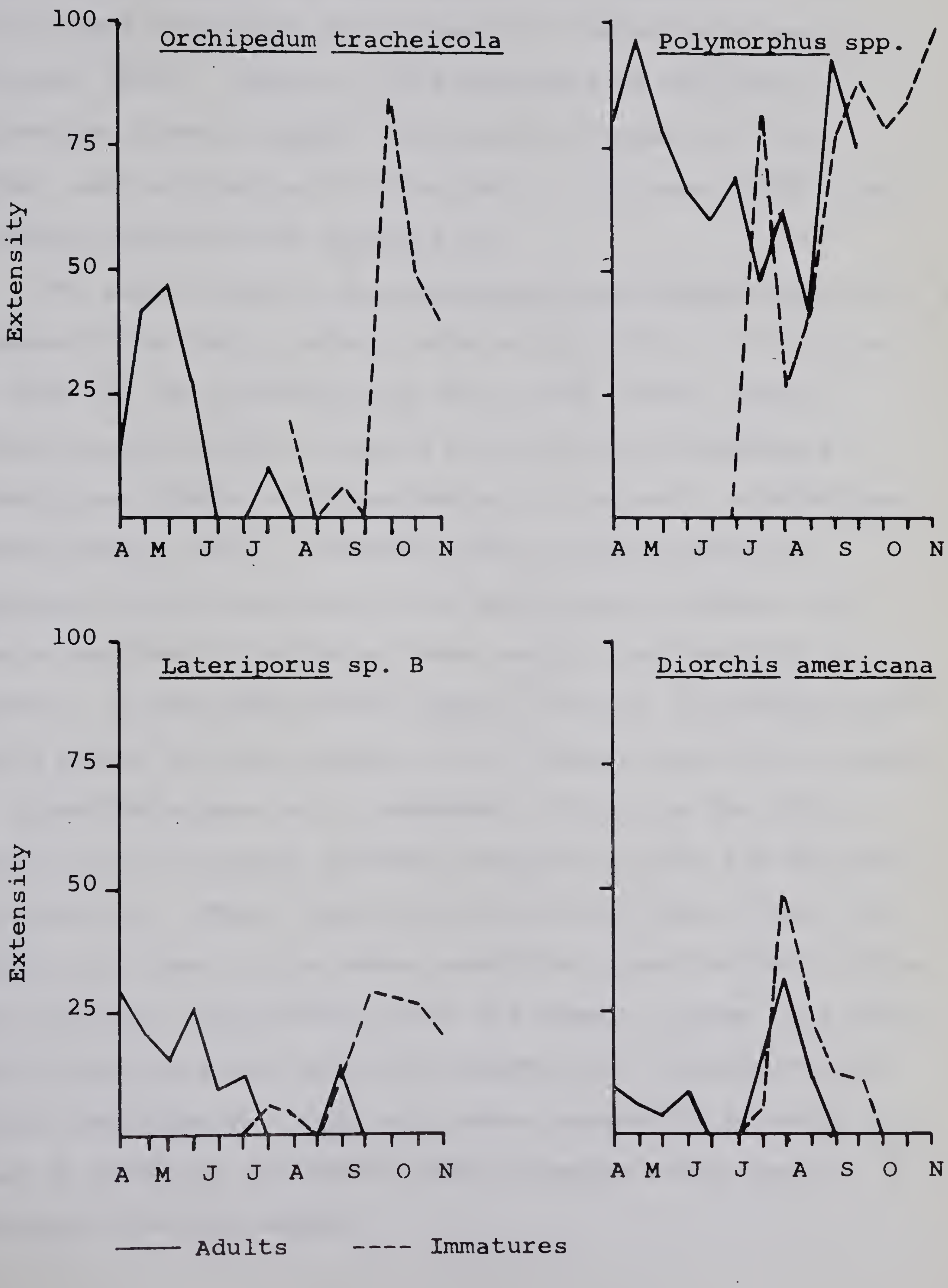
The other three helminths showing spring-fall peaks, Orchipedum tracheicola, Polymorphus spp. and Lateriporus sp. B (Fig. 27) are in an inhibitory or mostly inhibitory host, thus their life in the coot is probably short. If so, their extensity reflects exposure to infective stages of the helminths. All three apparently develop to the infective stage in gammarids. Thus it appears that the coots are infected in spring upon arrival (or possibly on their migration north) with helminths in overwintering gammarids. Then in summer, when the over-wintering generation of gammarids dies out (Menon, personal communication) the helminth infection drops until the new gammarid generation becomes infected in late summer. Gallimore (1964) found a similar pattern for Orchipedum tracheicola in grebes, where their development is also inhibited.

The complex of factors that produce the seasonal fluctuations in the condition of the coots might also be involved in producing this pattern of parasite abundance. Although there was no direct correspondence between the condition pattern and that of any of this group of helminths (see section on host condition), all showed spring-fall peaks, and, in general, the rise in either index of condition preceeded the rise in helminth numbers.

The third type, with a summer peak, is represented by Diorchis americana, D. ransomi, Neoleucochloridium problematicum, Echinostoma attenuatum, Notocotylus pacifera and Theromyzon rude.

Figure 27

Seasonal variation in extensity of Orchipedum tracheicola, Polymorphus spp., Lateriporus sp. B, and Diorchis americana.

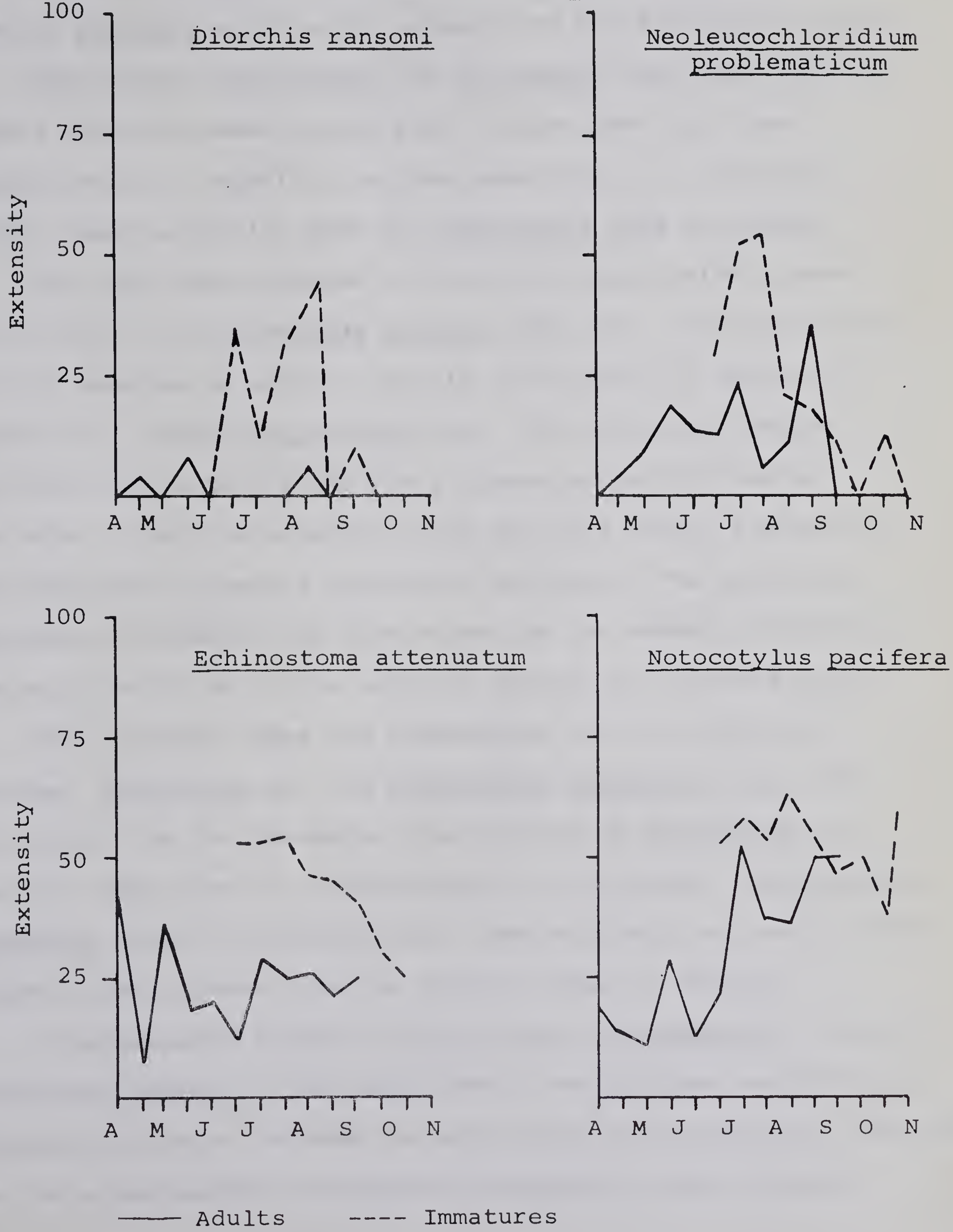


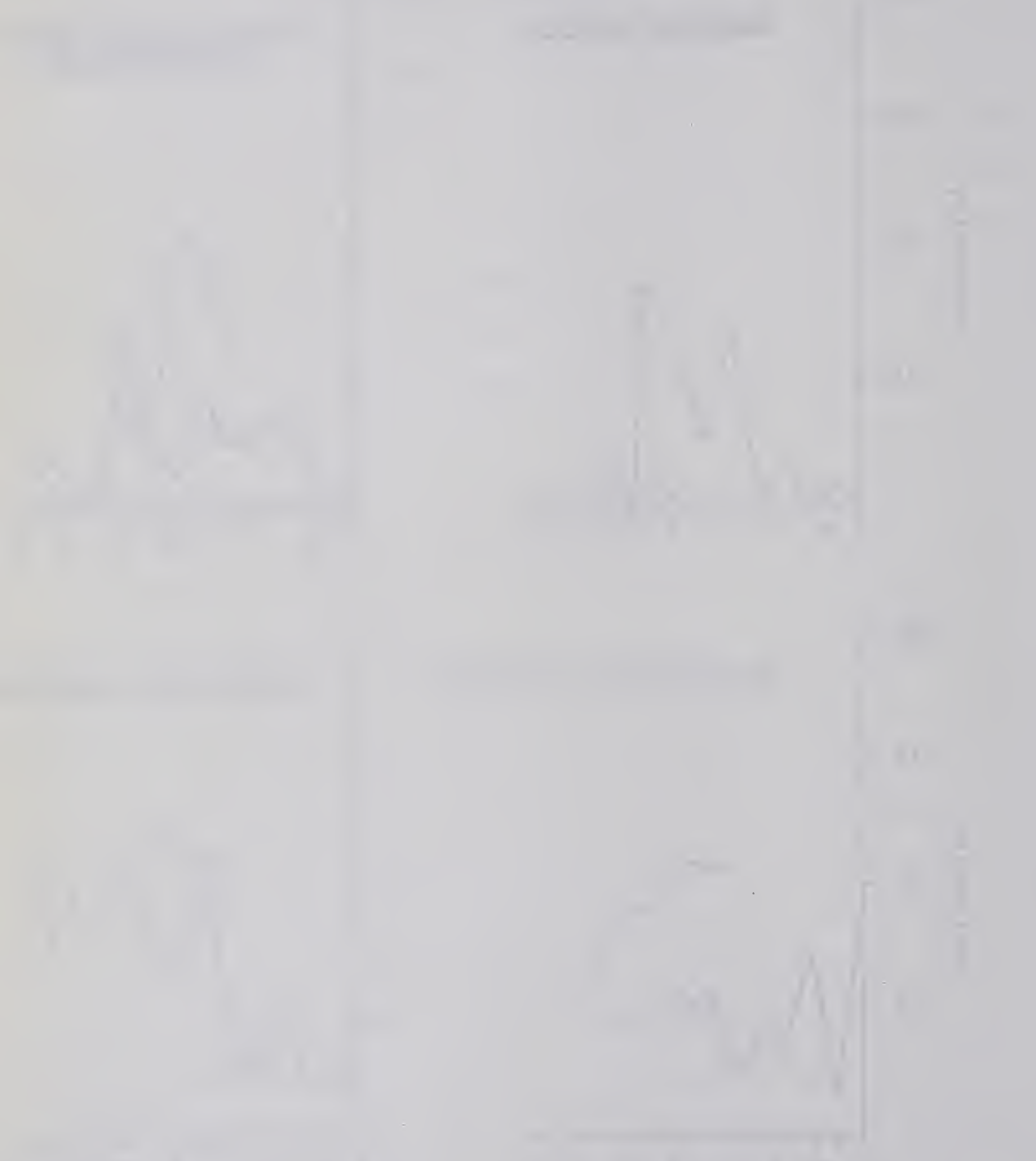
The two *Diorchis* species (Fig.27, 28) have a fairly rapid development in both their ostracod intermediate hosts and their avian final hosts (Jarecka, 1958a). The infection therefore builds up rapidly to a summer peak, which may reflect the high summer population peak known for some ostracod species (Pennak, 1953). Becuase of the sharpness of the peak of infection it would appear that the adult worms are short lived, not carrying on into the fall. Gallimore (1964) found a similar pattern with *Diorchis* sp.

The summer peak of *Neoleucochloridium problematicum* (Fig. 28) appears to be due to several interacting factors. The first is that the adult parasite is short-lived (Kagan, 1952). Second, approximately 3 months are required to develop a significant number of metacercariae in the snail intermediate hosts (Kagan, 1952). Woodhead (1935) reports that the succineid snails emerging in the spring were infected with larvae and that in Michigan these snails then died off in August. If the same pattern applies locally, the young snails which appear in June probably do not supply significant numbers of infective stages until September. Thus, the die off of older snails in August probably accounts in part for the drop in parasites. Third, for the first part of their lives, the young coots feed in the dense vegetation close to shore, where the succineid intermediate hosts are common. Later, the coots feed in the more open areas off shore, where succineids are rarely encountered. This last factor apparently prevents a rise of infection in the fall when juvenile snails may be carrying infective stages.

Figure 28

Seasonal variation in extensity of Diorchis ransomi, Neoleucochloridium problematicum, Echinostoma attenuatum, and Notocotylus pacifera.





Notocotylus pacifera (Fig. 28) had a very broad summer peak which was not well defined. The rise in extensity in November was based upon a very small sample of five birds, and is probably fortuitous. If this rise is characteristic, then *N. pacifera* would be an example of the fall peak pattern.

Echinostoma attentuatum and *Theromyzon rude* (Fig. 28, 29) showed definite summer peaks but I cannot make any clear suggestion as to specific factors governing it. Gallimore (1964) found a similar peak for *Theromyzon rude* in grebes.

The only clear example of the fourth type, with a peak in the fall, is *Polymorphus trochus* (Fig. 29). The life cycle of this species is unknown, but it is believed to develop in gammarids. Unlike *Polymorphus* spp., this helminth matures in coots and is maintained for a longer period of time in the bird. Thus the extensity does not fall during the period when the adult gammarid population declines. The extensity increases throughout the late summer as the number of infective larvae is built up by the constant seeding by infected coots.

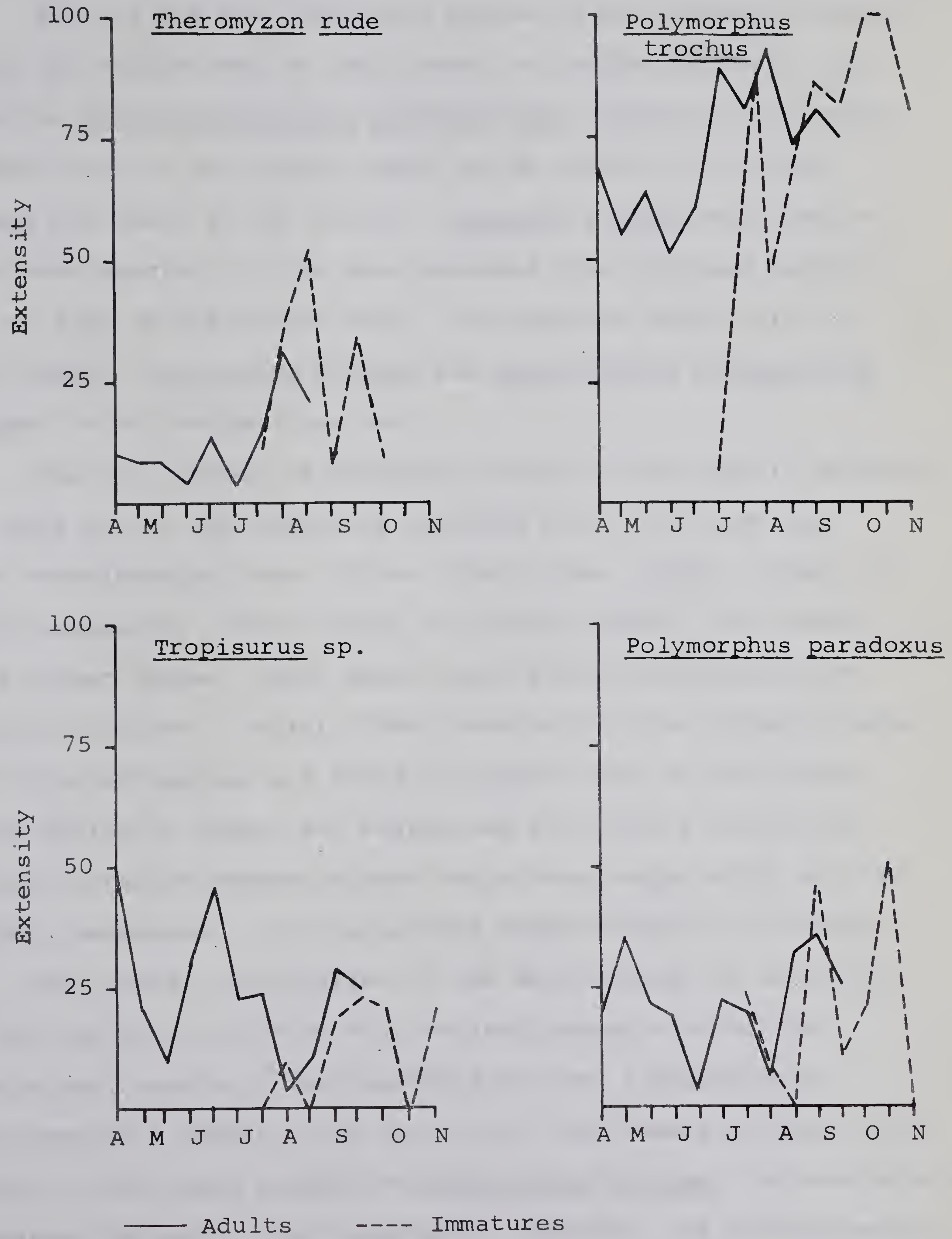
The irregular type was represented by two other major species, *Tropisurus* sp. and *Polymorphus paradoxus* (Fig. 29). The reason for the irregular fluctuations of *Tropisurus* sp. are not understood as intermediates are not known. *Polymorphus paradoxus* shows no clear pattern here although Gallimore (1964) found it had a summer peak in grebes, where it matures.

A seventeenth species, *Spirofilaria fulicaeatrae*, although relatively common in the local coots, has not been analyzed for seasonal variation because the efficiency of the recovery techniques for this species was considered inadequate to give reliable

[illegible]

Figure 29

Seasonal variation in extensity of Theromyzon rude, Polymorphus trochus, Tropisurus sp., and Polymorphus paradoxus.



results. Transmission of this parasite does not appear to take place locally, since no immature coots were ever found infected with it.

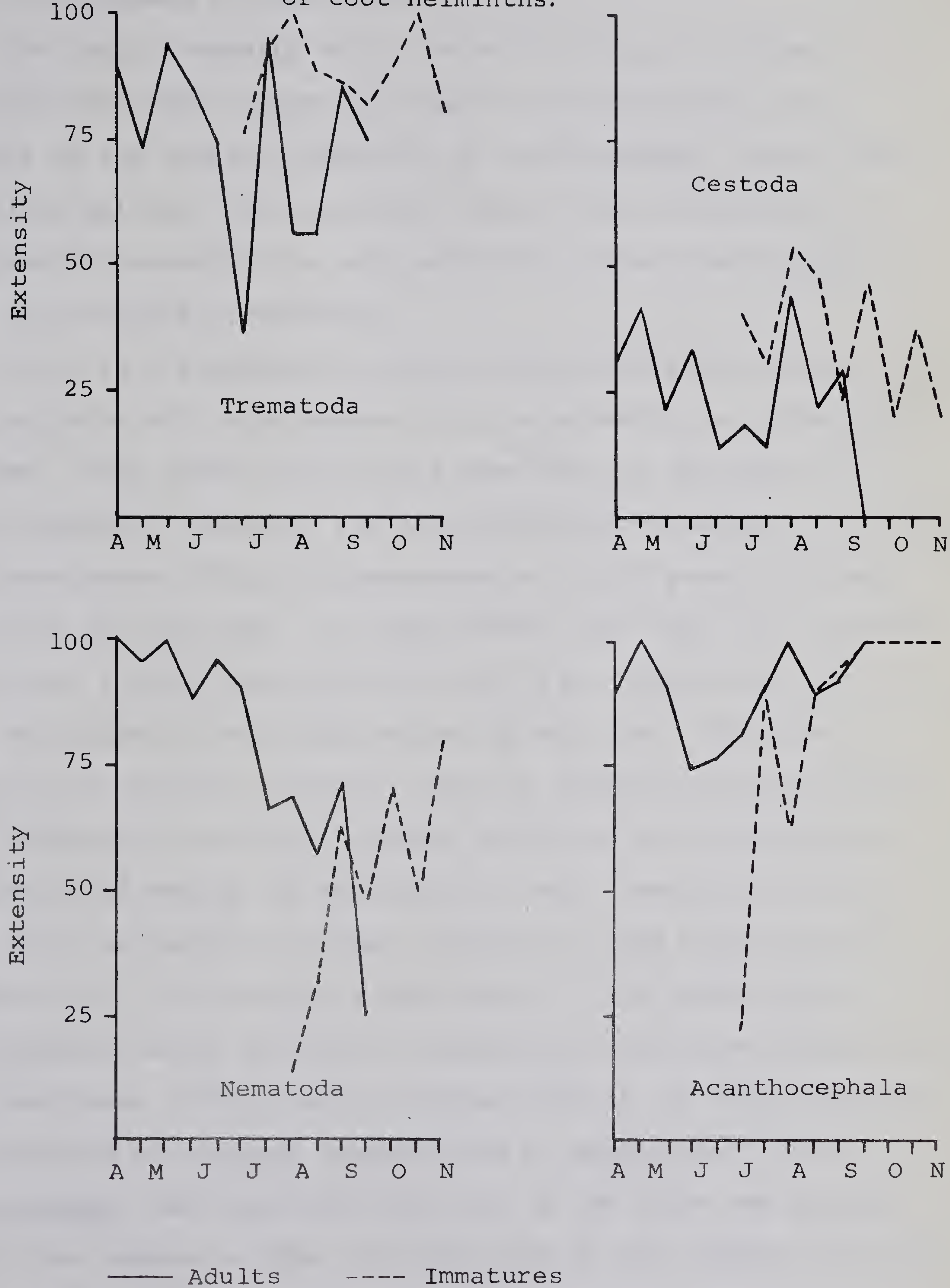
Most of the coot helminths appear to be "ubiquist" species (that is, transmitted on both summer and winter grounds). One species Neoleucochloridium problematicum, appears to be transmitted only n the summer range, as no records for winter range are known to the author. Diorchis ransomi may also be a "northern" species; it has been recorded from Oklahoma but this is on edge of the winter range. Two species found only in the adults, Capillaria fulicae and Spirofilaria fulicaeatrae, appear to be "southern" species.

The high number of "ubiquist" species in the coot is probably in part due to the extensive breeding area which overlaps the overwintering areas (Jones, 1940; Ryder, 1963). There is also apparently little change in feeding habits in summer and winter (Jones, 1940) which would also encourage similar helminth faunas. Dogiel (1964) reports that the highest number of "ubiquist" species are found in species that do not change food habits in summer and winter and that have a relatively short migration between summer and winter ranges which are not widely separated. My observations support Dogiel's findings.

The overall extensities of the major groups of helminths (Fig. 30) do not show as well defined patterns as do the individual species. The nematodes do show a spring peak, followed by a general drop off to the late summer and fall level which is the basic pattern of Amidostomum fulicae, the predominate nematode helminth. The trematodes, cestodes, and acanthocephala

Figure 30

Seasonal variation in extensity of the major groups of coot helminths.



fluctuate irregularly, but all show a drop in extensity in June, which appears to correlate with the breeding season. This will be discussed further below.

The total intensity of all helminths (Fig. 31) shows a strongly developed pattern with spring and fall peaks, due largely to the overall intensity of acanthocephala, which shows a similar pattern. Both probably reflect the availability of infected gammarids, as outlined above. The other groups tend to fluctuate irregularly.

There is a suggestion in many of the spring and spring-fall patterns of a superimposed drop in extensity of infection in June. This takes place at the same time as the drop in total trematode, cestode, and acanthocephalan extensity mentioned above. From the measurements of the gonads of coots autopsied in this study, the peak testis size (Fig. 32) occurred in mid-May and the peak follicle size (Fig. 33) in late May. Both measurements were much reduced by mid-June. Thus the drop in the helminth infection seems to correlate more with the late incubation and early brooding period in June rather than the period of mating and egg-laying in May. Reasons for this drop could be hormonal changes, changes in food habits and/or a reduction in the amount of food eaten. The latter is not the probable reason as this is a period of increasing fatness (Fig.24)

Gallimore (1964) found a similar drop in the total intensity of helminths of _Podiceps caspicus_ and _P. auritus_ but not of _P. grisegena_. He correlated the drop in the first two species, which also occurs in June, with the size of the largest follicle in the females, therefore with egg laying and/or incubation.

Figure 31

Seasonal variation in intensity of the major groups of coot helminths.

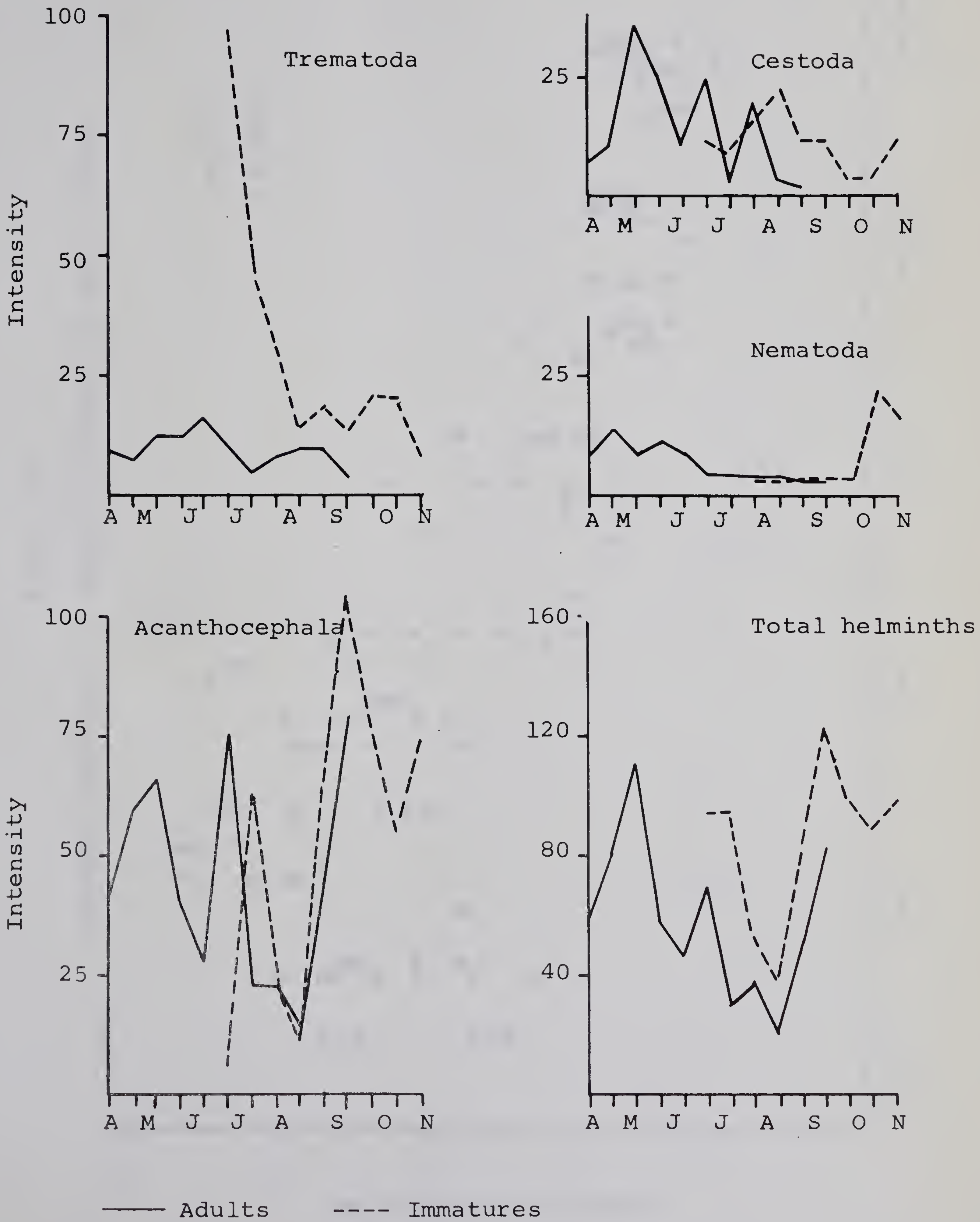
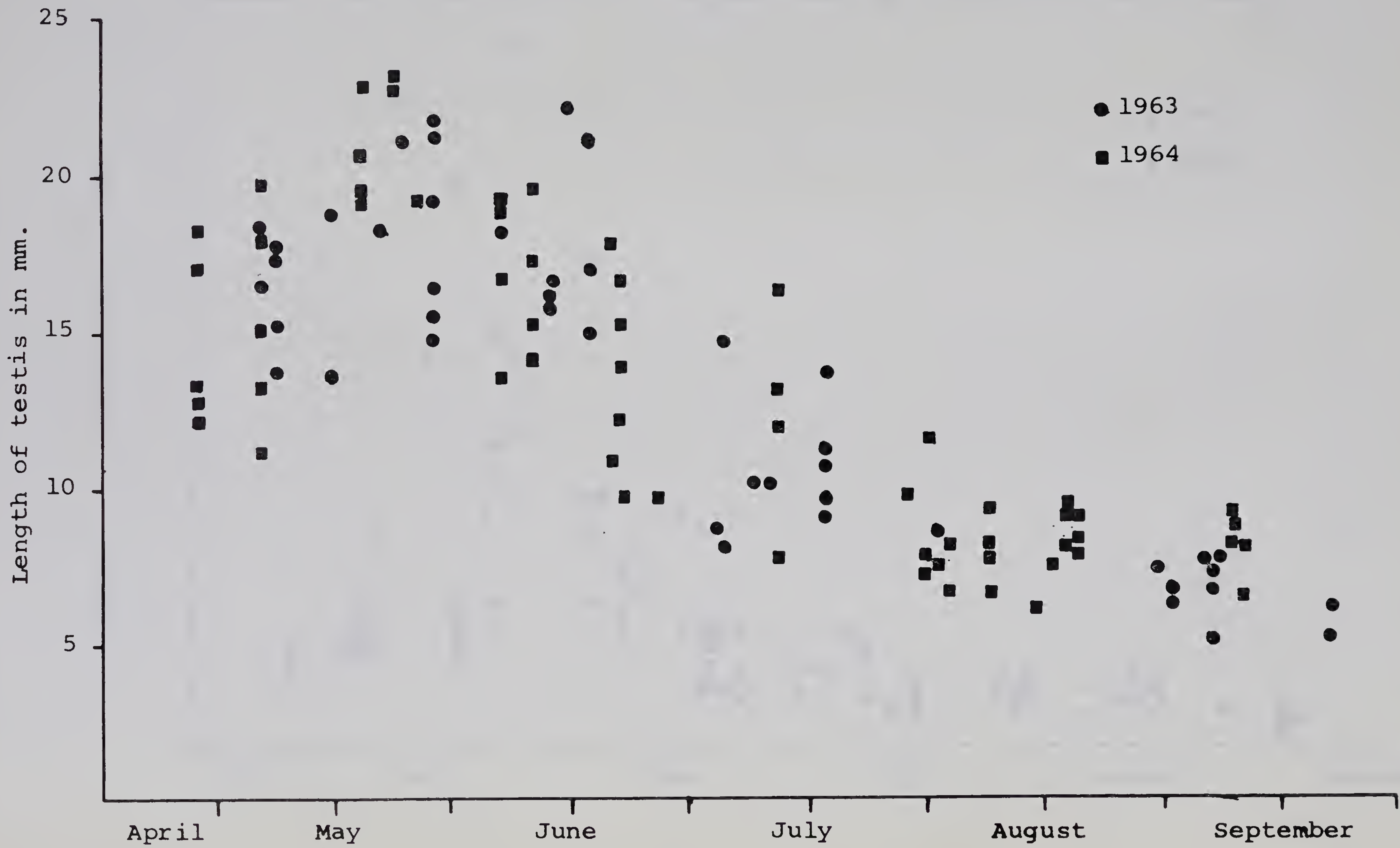


Figure 32

Seasonal variation in length of testis in adult coots.



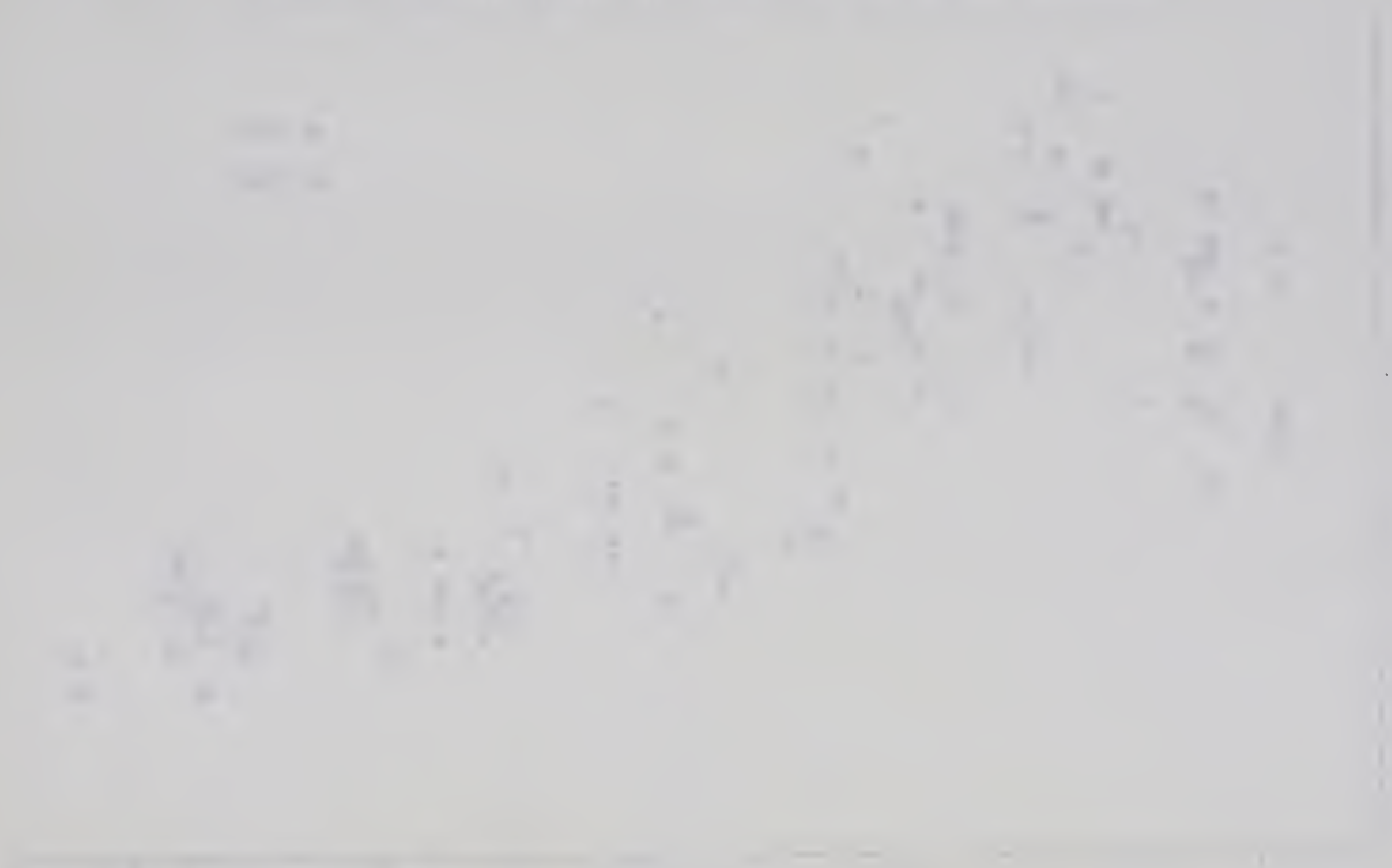
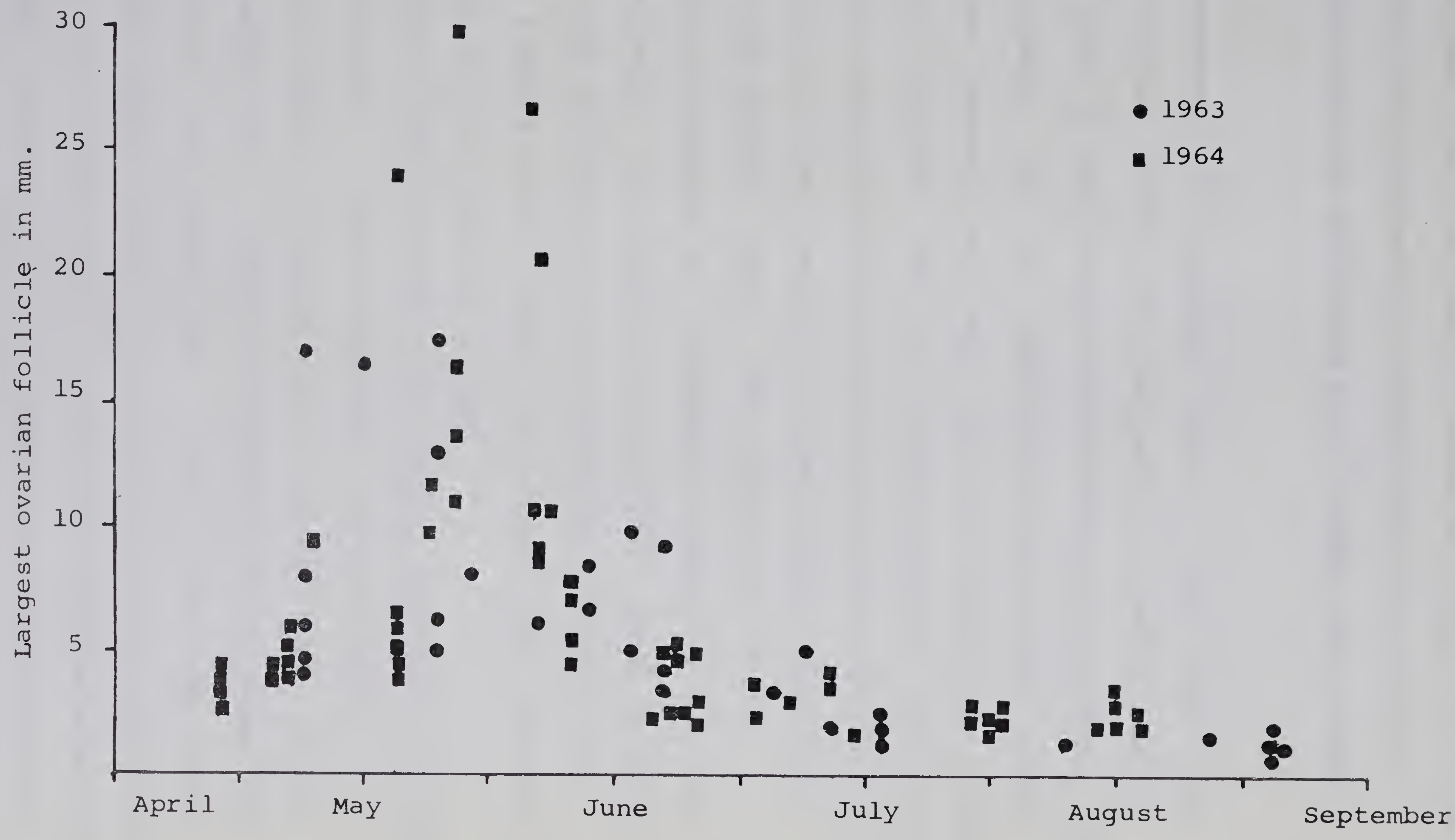


Figure 33

Seasonal variation in size of largest ovarian follicle in adult coots.



It is thus clear that certain seasonal changes do occur and that they are produced by a combination of parasite, intermediate host and definitive host biology and ecology.

Habitat

Differences in the parasite faunas of water birds from different habitats within the same general climatic region have been shown by many authors (Bychovskaya-Pavlovskaya, 1962, and Sulgostowska, 1963, for trematodes; Korpaczewska, 1963b, for cestodes; Cornwell and Cowan, 1963, for helminths of *Aythya valisineria*; Gallimore, 1964, for grebe helminths; *inter alia*). This is not a surprising result if one considers the considerable variation of the limnology of even closely associated lakes shown by Kerekes (1965). The composition of the invertebrates, important as intermediate hosts, is included in this variation. The density of definitive hosts, determined largely by the suitability of the available habitat, will affect the seeding of the habitat by helminth eggs, and thus the availability of infective stages.

Gallimore (1964) divided local aquatic habitats into ponds, sloughs, and lakes. "Ponds" were small isolated bodies of water under 2 acres in surface area. "Sloughs" were larger bodies of water with no thermal stratification in summer and without a stable fish population. "Lakes" were large bodies of water with summer thermal stratification and a stable fish population. All bodies of water from which coots were collected in this study, with the possible exception of Hastings Lake, would fall into the category of "sloughs". Hastings Lake, which has a stable fish population (*Esox lucius* and *Perca*

flavescens), but no summer thermal stratification, seems to be borderline between the slough and lake habitats.

Since moderately large samples of coots were collected from Hastings Lake, Cooking Lake, and from miscellaneous sloughs, I had the opportunity to test for differences in the helminth faunas of coots from different habitats within one of Gallimore's categories.

The data on intensity and extensity of the major helminth species collected from coots from these three habitats from mid-May to the first of September are given in Appendix II. The reason for this period of comparison is my observation that the coots appear to move about from area to area before and after, but not during, this period.

The structure of the helminthofauna of coots from the three habitats is shown in Table IX. The total number of helminth species in the three habitats were very similar; however coots from sloughs had a more diverse trematode fauna and a less diverse nematode fauna than the two lakes. Little or no differences were found in cestodes, acanthocephalans and leeches. Sloughs had the largest number of species found only in one habitat with four, as compared to two in Hastings Lake and one in Cooking Lake. All these species occurred in only one bird with five being in an accidental host and the other two in an inhibitory host. All the common helminths, and almost all of those for which the coot is a main or auxiliary host, were found in all three habitats.

Coots from Cooking Lake had the highest intensity of helminths followed by those from sloughs and then Hastings Lake.

Table IX. Structure of helminthofauna of coots from three habitats.

	Sloughs	Cooking Lake	Hastings Lake
No. of birds examined	75	91	77
No. of species of trematodes	13	10	9
No. of species of cestodes	7	6	7
No. of species of nematodes	4	7	7
No. of species of acantho-cephala	4	4	4
No. of species of leeches	1	1	1
Total no. of helminth species	29	28	28
No. of species found only in one habitat	4	1	2
Intensity (average no. of parasites per bird)	52.9	76.1	43.9

The difference between helminth numbers in coots from Cooking Lake and from the other two habitats is probably due to the uniformity and large size of Cooking Lake, allowing for a high population of coots and other birds, thus increasing the seeding of the invertebrates. The latter are also more abundant in Cooking Lake than in Hastings Lake at least (Kerekes, 1965).

The comparison of the three areas by extensity and intensity of the various groups of helminths is shown in Figures 34 and 35. In extensity of infection, as in helminthofaunal structure, sloughs appear to differ from the two lakes. This is particularly evident in acanthocephala in immature coots, and in trematodes and total helminths.

The intensity data (Fig. 35) show a different picture. The trematodes of both adult and immature coots were highest in sloughs, moderately high in immatures from Cooking Lake and comparatively low in both ages in Hastings Lake. The same pattern was evident in the cestodes of immature coots. The nematodes showed no significant differences between areas. All other groups were highest in the coots from Cooking Lake. Hastings Lake coots had the lowest intensities of trematodes and cestodes but higher intensities of acanthocephala than coots from sloughs.

Therefore, coots from sloughs were characterized by a large number of species and a high intensity of trematodes and a low extensity and intensity of acanthocephala. Cooking Lake coots were characterized by a high or relatively high extensity of all helminth groups with a high intensity of cestodes and

Figure 34

Variation in extensity of helminths from coots from three habitat types.

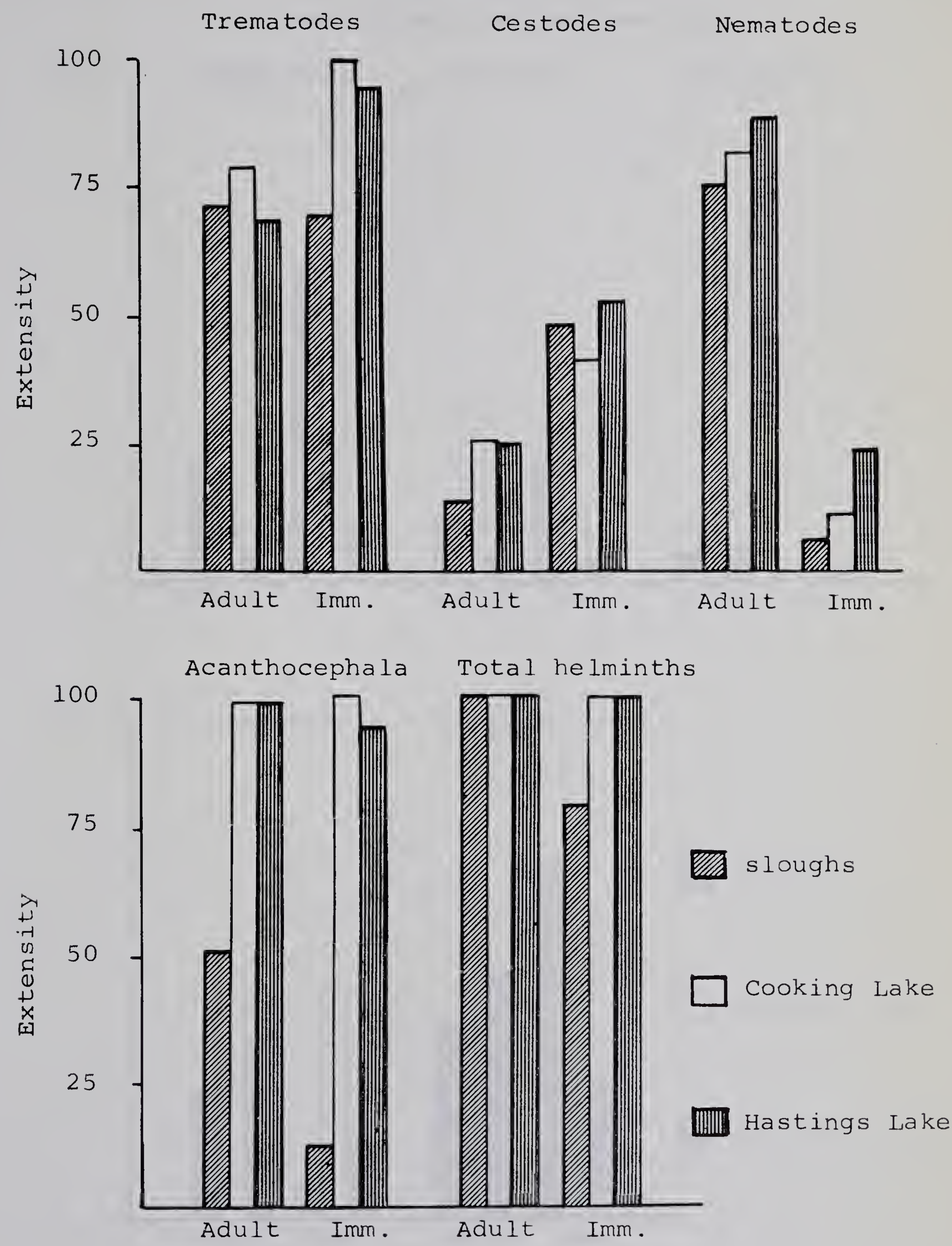
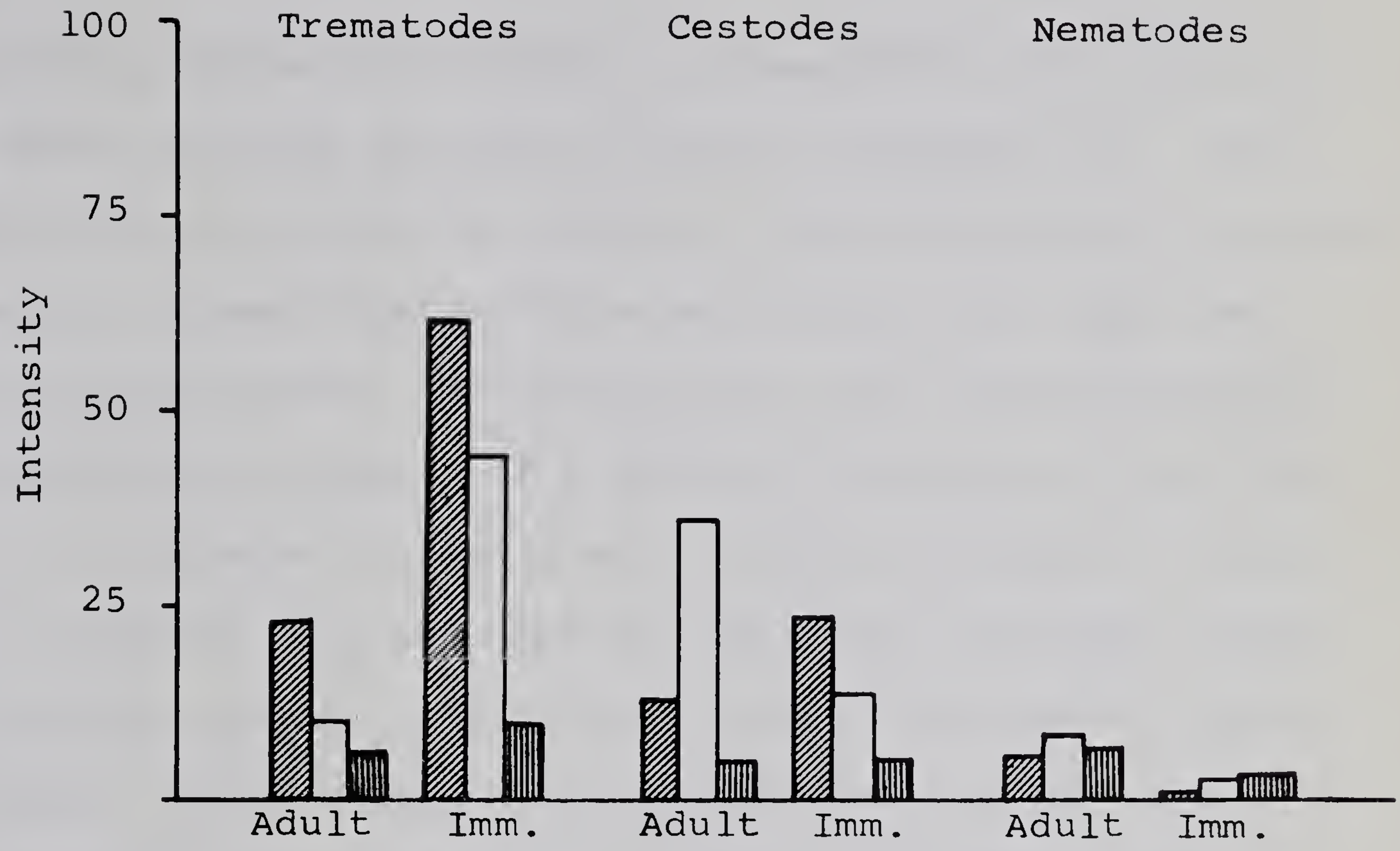
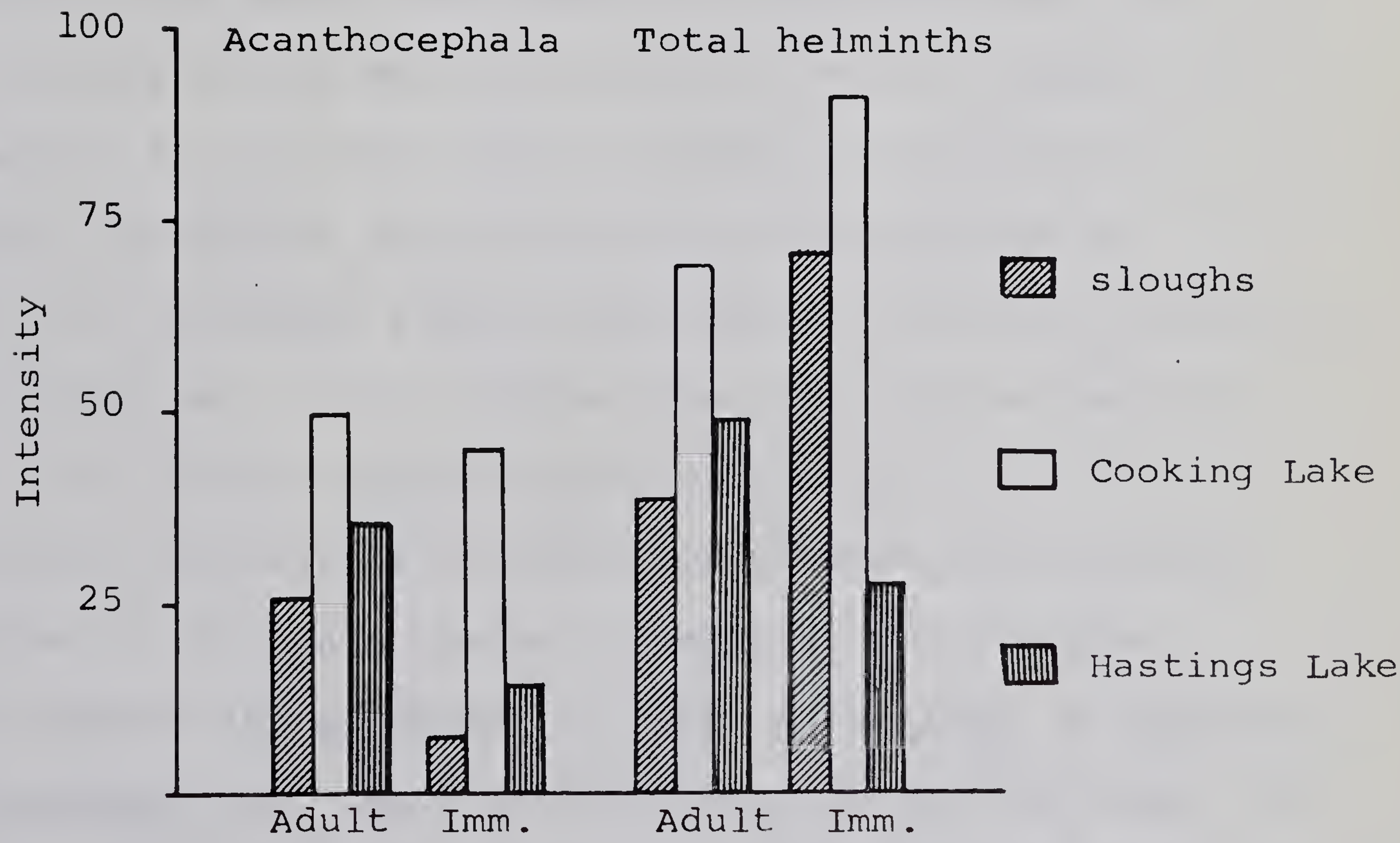


Figure 35

Variation in intensity of helminths from coots from three habitat types.





acanthocephala. Coots from Hastings Lake were also characterized by a high extensity of all helminth groups but a relatively low intensity of all groups except for acanthocephala in adults.

A rating system was devised to compare the relationships of the major helminth species to habitat (Appendix II). This was done by giving relative values to the extensity and intensity of infection of each species from each habitat for each two-week collecting period. The ratings for each two-week period were assigned as follows: if a parasite occurred in all three habitats at different rates in each, they were rated 1-3 from lowest to highest. If two were the same and one higher, they would be given ratings of 1, 1, and 2 or if the one was lower 1, 2, and 2. If the species was absent from one then the other two were rated as 3 and 4 in order of infection and if only one habitat sample contained the species it was given 5. These relative values were then totaled for the eleven two-week periods to give the values in Table X. This is an artificial comparison of habitats which was devised to eliminate the seasonal effects included in the actual infection values themselves. It is obvious that this can be used to compare the habitats species by species only.

General patterns of distribution of individual species are evident in the data listed in Table X. Five of the fifteen species (C. mutabile; T. atra, A. fulicae, P. paradoxus and Polymorphus spp.) were more abundant in the two lakes than in sloughs reflecting the size of the body of water from which the host was collected. Six species (N. problematicum, N. pacifera,

Table X. Comparison of major helminth species of coots from three habitats.

(Values given are rankings of data in Appendix II. See text for method.)

	Sloughs		Cooking Lake		Hastings Lake	
	Ext.	Int.	Ext.	Int.	Ext.	Int.
Cyclocoelum mutabile	7	9	14	11	10	11
Cyclocoelum oculeum	3	4	6	6	19	16
Neoleucochloridium problematicum	23	23	31	34	13	11
Echinostoma attenuatum	32	32	23	29	15	9
Notocotylus pacifera	17	19	36	32	19	18
Tanasia atra	13	8	17	18	17	18
Diorchis americana	14	12	20	22	14	14
Diorchis ransomi	19	19	12	12	6	6
Lateriporus sp. B	8	8	17	19	10	8
Amidostomum fulicae	11	12	20	22	22	22
Tropisurus sp.	15	15	14	13	17	18
Polymorphus trochus	9	12	34	32	19	21
Polymorphus paradoxus	8	8	25	26	26	25
Polymorphus spp.	10	12	27	27	34	33
Theromyzon rude	19	15	25	28	16	17

D. americana, Lateriporus sp. B, P. trochus and T. rude) were more abundant in Cooking Lake than in the other two reflecting the uniformity of the former as compared to the discontinuous nature of the coot habitat in the latter.

Of the other four species, one (Tropisurus sp.) showed no difference in the three habitats. C. oculeum was more abundant in Hastings Lake than in the other two; both E. attenuatum and D. ransomi were least abundant in Hastings Lake, intermediate in Cooking Lake and most abundant in sloughs. The reasons for these distribution patterns were not evident.

The differences shown above are less distinct than those Gallimore (1964) found between ponds, sloughs and lakes. However, they show that differences do exist between habitats which fall into one of his broad categories, namely sloughs.

INFLUENCE OF FOOD HABITS

A detailed analysis of 801 coot stomachs collected from all over North America and during all parts of the year was made by Jones (1940). The stomach contents from Alberta coots were analyzed in order to attempt to correlate helminth burdens with food present in the gizzard.

The gizzard contents were preserved in 70% alcohol at autopsy and later analysed grossly for major food types. The total animal material, as a proportion of total food present, was estimated, then the identifiable animal material was removed for later identification. Most material was not identifiable beyond a broad category because it was badly fragmented by action of the gravel in the gizzard.

The insect material was identified by Dr. G. Ball, Department of Entomology, University of Alberta, Edmonton.

A list of the food items, and their per cent occurrence in the coots examined in this study, is given in Table XI. Several insect groups occurred in significant proportions, but none of them is known to be an intermediate host of any of the species of the helminths of coots found in this study. (This does not mean that they do not serve as intermediate hosts; many life cycles are still unknown.) Snails were also found in significant numbers; these are known to serve as intermediate hosts of the trematodes. Gammarids are known to serve as intermediate hosts for *Polymorphus* species, *Orchipedum tracheicola* and for several cestodes, among which are some of the immatures found here.

Bychovskaya-Pavlovskaya (1962) points out that the diversity

Table XI. Per cent of occurrence of food items from gizzards of coots.

Food	Young	Adult	Total
Plant Material	100	100	100
Unidentified plant	100	100	100
Seeds	65.0	58.5	60.9
Duck weed	22.0	23.1	22.7
Algae	17.1	23.5	21.1
Animal Material	67.1	73.4	71.0
Insecta	59.3	70.3	66.1
Insect fragments (unidentifiable)	55.7	56.7	56.4
Diptera	10.7	13.9	12.7
Chironomidae	7.1	13.9	11.3
Stratiomyiidae	0	.4	.3
Tabanidae	0	.4	.3
Therevidae	.7	0	.3
Heleomyzidae	.7	0	.3
Coleoptera	7.1	10.4	9.2
Dytiscidae	5.0	5.7	5.4
Haliplidae	1.4	.4	.8
Scarabeidae	0	1.3	.8
Curculionidae	.7	.8	.8
Hydrophilidae	.7	.4	.5
Helodidae	0	.8	.5
Elateridae	0	.4	.3
Bupestridae	0	.4	.3
Chrysomelidae	0	.4	.3
Hemiptera	7.8	4.8	5.9
Corixidae	7.1	4.3	5.4
Notonectidae	.7	0	.3
Nabidae	0	.4	.3
Lygaeidae	.7	0	.3
Trichoptera	2.8	2.6	2.7
Limnephilidae	1.4	1.3	1.4
Phryganeidae	0	.8	.5
Hydropsychidae	0	.4	.3
Molannidae	0	.4	.3
Odonata	.7	3.1	2.1
Coenagrionidae	.7	.8	.8
Aeshnidae	0	.4	.3
Hymenoptera	0	1.3	.8
Apidae	0	.8	.5
Formicidae	0	.4	.3
Homoptera	0	.4	.3
Aphididae	0	.4	.3

cont'd

Table XI. cont'd

Food	Young	Adult	Total
Mollusca	13.6	10.0	10.5
Snail shells	8.5	9.6	9.2
Lymneidae	0	2.1	1.3
Physidae	2.8	0	1.1
Planorbidae	.7	0	.3
Gammarids (<u>Gammarus</u> sp., <u>Hyalella</u> sp.)	9.3	6.1	7.3

of the biohelminths of any host species is determined by the diversity of food eaten by the host. The relatively diverse food habits and helminth fauna found in the present study supports this conclusion. Bychovskaya-Pavlovskaya also correlated an aquatic environment with a diversity of trematodes, corroborated in this study by trematodes having the largest number of species of any helminth group.

However, Rybicka (1957a, b) and Jarecka (1958a) have shown that the intermediate hosts for D. ransomi (and the probable intermediates for D. americana) are ostracods. Kagan (1951) showed that the intermediate for N. problematicum was a succineid snail. Neither of these intermediates were identified from the material in the stomachs of coots, either in this study or in that of Jones (1940), even though both helminths are common coot parasites. The intermediates for Schistocephalus solidus, fish, probably sticklebacks, were not found in this study and in only 3 of 801 coots by Jones. The occurrence of gammarids was also lower than one would expect from the infestation with acanthocephala, especially Polymorphus spp., which is probably short lived.

It is very clear that food analyses of this type do not reveal all the possible intermediates of even the common parasites and most certainly do not reveal the proportions in which they are ingested. A comparison of the food and parasite data leads one to two definite conclusions: one, that only the more resistant forms of food are maintained in the stomach for any period (and thus stomach analyses do not give an accurate picture of the birds' feeding habits), and two,

that the parasite fauna may reveal certain food items not shown by conventional food analyses.

The seasonal distributions of the major types of food (expressed as per cent occurrence) are shown in Figures 36 and 37. (Unidentifiable plant material is not shown in this figure; it occurred in all gizzards.) It is evident that seasonal changes in food habits do occur, probably due to the availability of the food and/or food preferences of the coots. It is also immediately apparent that coots are omnivorous, but feed to the greatest extent on plant material, which occurred in all stomach contents.

The seasonal variation in the percentage of animal material in the diet, which is obviously the most important portion of the food from a parasitological point of view, is shown in Figures 36 and 37. The amount of animal material in the diet was greatest between the first part of May and the end of July, fell to a low in August, then rose slightly in September, which is in general agreement with the results obtained by Jones (1940). The August low and September rise in animal food correlates well with total helminth intensity (Fig. 31). It is interesting to note that the percentages of animal material in the diet of adults and immatures are very similar. This similarity is also shown in the occurrence of insects and gammarids. Snails, however, are higher in immatures, which correlates with the higher trematode infections of immatures (Fig. 21). The highest intensity of trematodes in adults also occurs during the period from the first of May to the end of July (Fig. 31) when they were found feeding on

Figure 36

Seasonal variation in major categories of the food of the coots collected in this study.

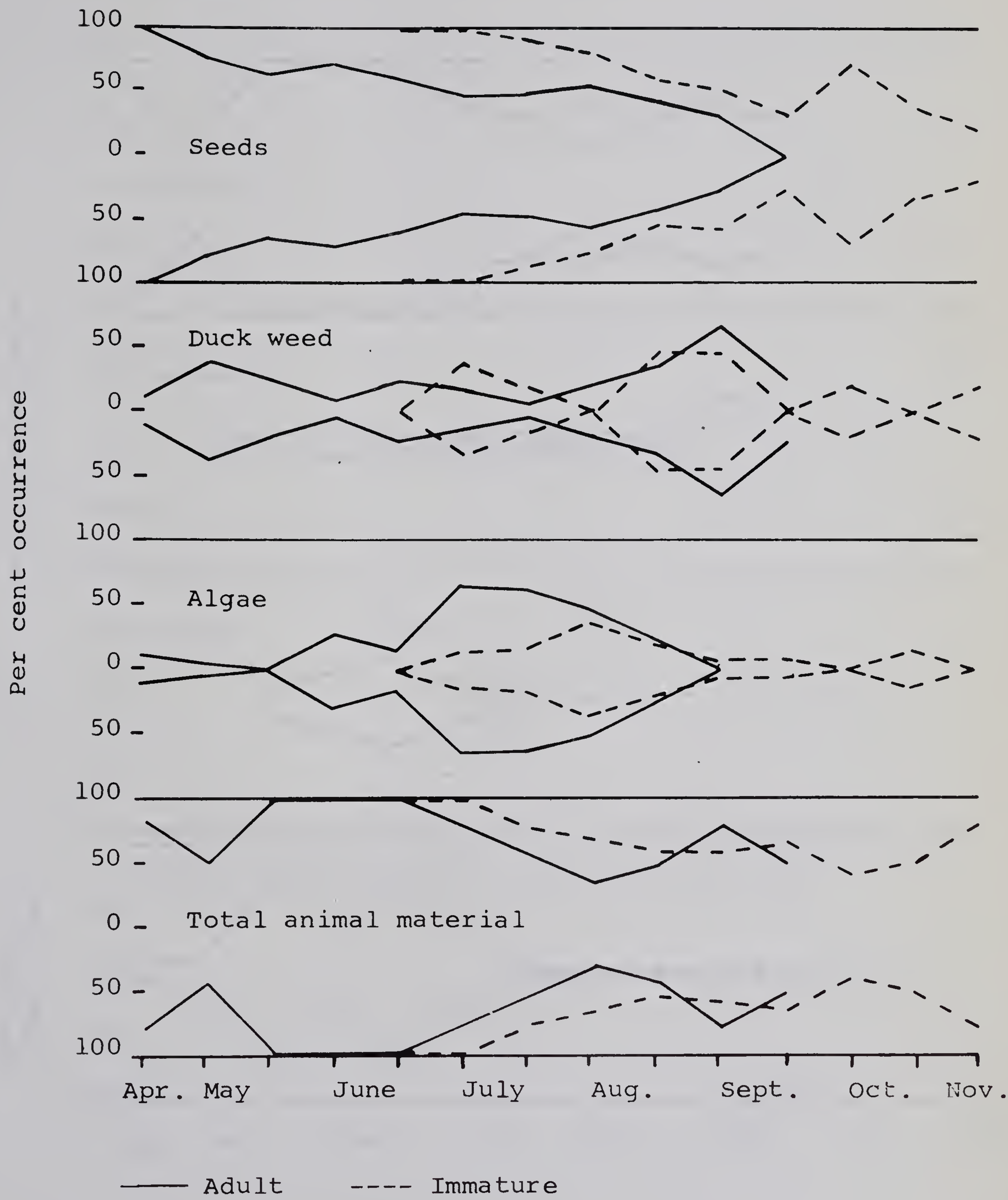
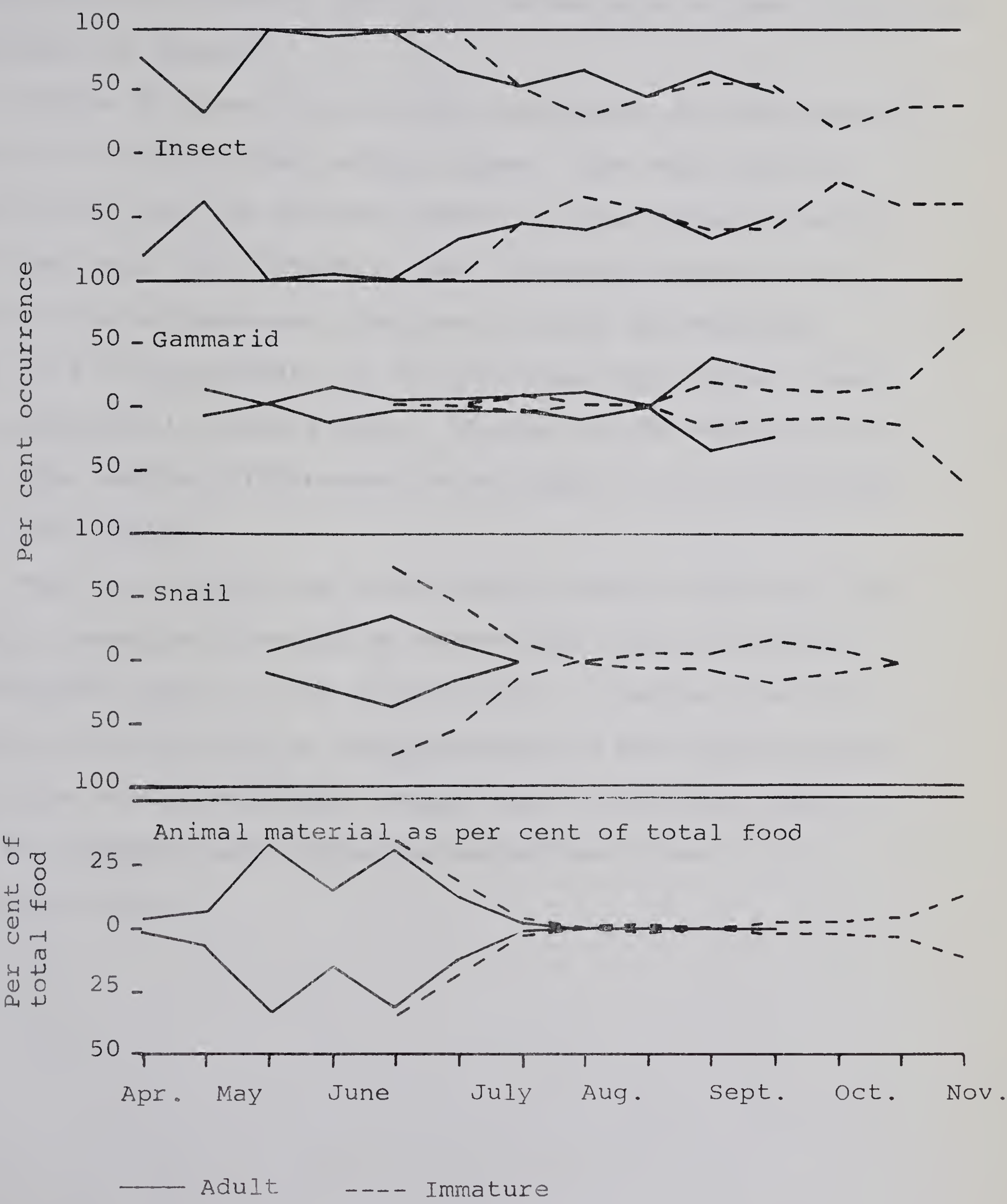


Figure 37

Seasonal variation in animal material in the food of the coots collected in this study.



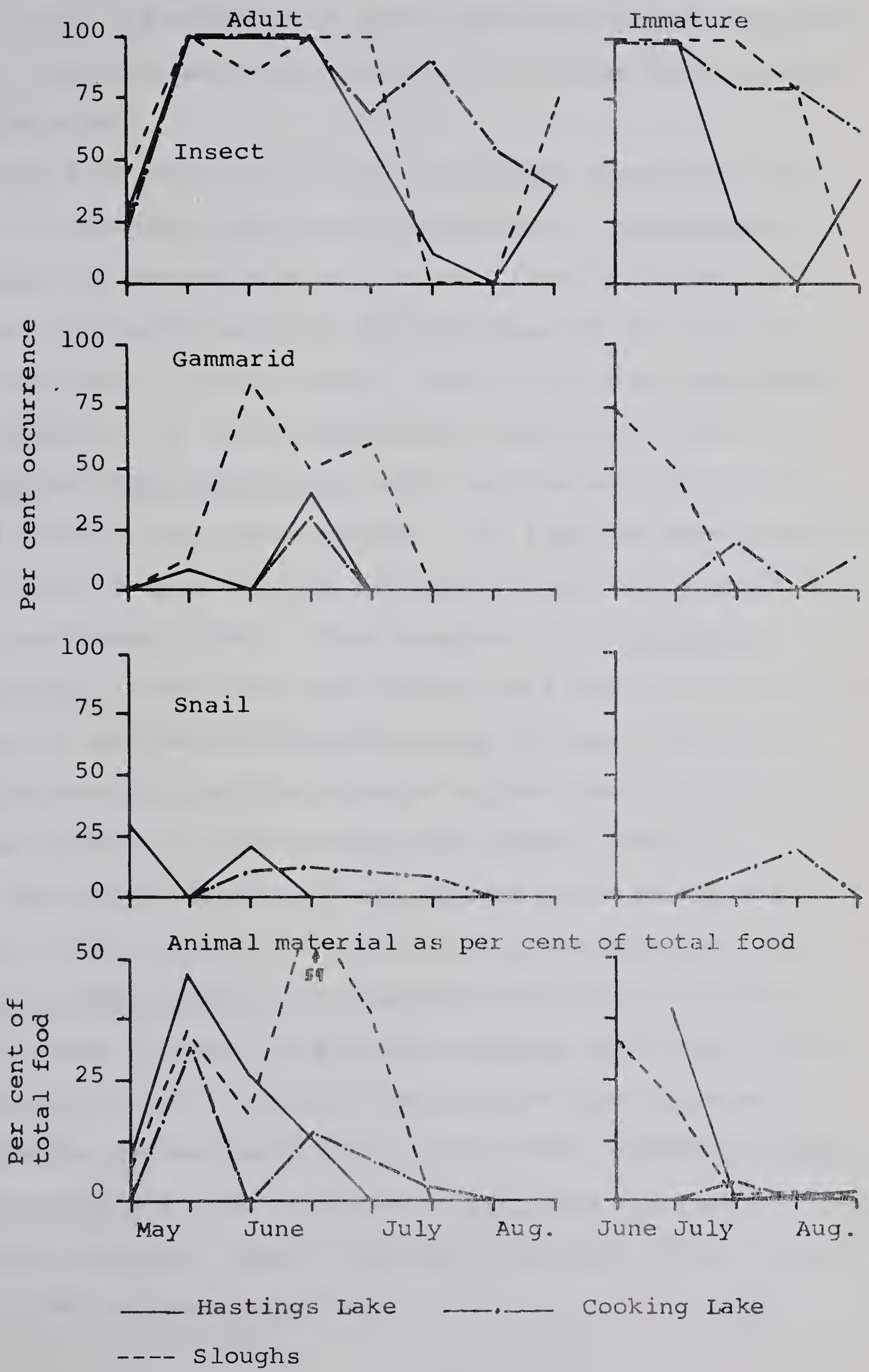
snails (Fig. 37). The increase in gammarid intake in September also correlates with increased acanthocephalan intensity (Fig. 31). Insects are not known to be an important intermediate host for major coot parasites and no definite peak of infection can be tied in with them but not all intermediates of coot helminths are known at present.

Figure 38 shows the per cent occurrence of animal material in coots from the three habitat types. The only positive correlation with the helminth fauna is given between snails and trematodes from sloughs. The difference between snails in the food of immatures from Cooking Lake and Hastings Lake is also significant as it correlates with larger number of trematodes in Cooking Lake. Insofar as the analysis goes, the other habitat differences do not appear to be correlated with food habits.

Food is no doubt one of the major factors affecting the overall parasite infection by controlling the availability and maximum limits of the biohelminths. I believe that the effect of the biology of the parasites and the physiological condition of the host play a major part in modifying this initial exposure into the actual infections found in a definitive host.

Figure 38

Variation in the animal material in the food of coots from three habitat types.



PATHOLOGY

Although pathology was not specifically investigated in this study, all evidence of gross pathology encountered were noted. Such evidence was found in most of the birds examined in this study.

All four helminths of the respiratory system of coots were of potential pathological importance. *Cyclocoelum mutabile* was encapsulated by air sac tissue in three birds; encapsulated material which may have been of this species was also found in other birds. This may be the normal method of elimination of these large worms from the air sacs. *C. oculeum* and *Theromyzon rude*, both large worms found in the nasal cavity, may cause blockage. (*T. rude* has been suggested as a cause of death through blockage of the air passages by Meyer and Moore, 1954). These species, plus *Orchipedum tracheicola* in the lungs and trachea, all feed on blood or host tissue and may cause extensive damage in heavy infections. The cyclocoelids could also cause serious damage during their tissue migration (Ginetsinskaya and Saakova, 1952).

None of the trematodes or cestodes found in the digestive system in this study were observed to cause pathology although *Sphaeridiotrema globulus*, a trematode not encountered here, caused death in coots in Wisconsin (Trainer and Fisher, 1964). Neither of the two nematodes found in the intestines were observed to produce pathology in this study, although *Strongyloides avium* and other species of *Capillaria* are known to cause pathology (Lapage, 1959). All other helminths of the digestive tract produced some pathology.

Fibrotic ulceration of the proventriculus was produced by heavy infection of either species of *Echinuria.* Proventricular glands infected with *Tropisurus* sp. were enlarged. The single *Streptocara* sp. encountered was in a detritus filled cyst on the outer wall of the proventriculus. In no case did the function of the proventriculus appear seriously impaired.

Amidostomum fulicae sometimes produced inflammation of the mucosal layer of the ventriculus. This reaction was limited to small areas surrounding aggregates of worms, which were generally found around the pylorus. The inflammation did not appear to seriously effect ventricular function.

All of the acanthocephala produced some local tissue damage at the site of attachment. In addition, well developed specimens stimulated a fibrotic reaction. *Polymorphus trochus*, which matured in coots, and probably remain longer than other species not maturing, stimulated the production of a fibrotic nodule which protruded from the serosal surface. In many cases calcification also occurred in these nodules. Even large numbers of these nodules did not appear to be debilitating.

Tanasia atra infections in the kidney did not produce visible evidence of pathology. *Spirofilaria fulicaeatrae* caused minor nodule formation in the tarsal joints of a few coots, but not the pronounced lesions produced in red-necked grebes (Gallimore, personal communication). This may be due to the lack of heavy infections with these filarids in the coots examined in this study.

Two serious cases of non-helminthic pathology were noted. In one case, large fibrous cysts, ulcers and some calcification

occurred in the liver, intestines and kidney. The liver was greatly enlarged and pulpy and the infected areas of the intestine were also greatly enlarged. The causal agent is unknown. In the other case, a greatly enlarged, clogged Bursa of Fabricius filled the body cavity, partially destroying one kidney. The other kidney was enlarged. This condition was apparently caused by a sheet of tissue obstructing the cloaca, which at the time of examination, allowed passage of detritus. The material in the bursa was hard and black, giving the impression that the condition was a long-standing one.

In conclusion, no birds appeared to be seriously impaired by the helminth infections present, despite the frequency of minor pathological conditions. The only two cases that appeared to be serious were non-helminthic.

SUMMARY

The helminth fauna of 371 American coots (Fulica americana) collected during the summers of 1963 and 1964 near Edmonton was investigated. Thirty-six species of helminths, including 14 trematodes, 9 cestodes, 8 nematodes, 4 acanthocephala and 1 leech, were recovered. Ten of these were new host records and two were new North American records.

Gallimore's (1964) categories of host-parasite relationships were used to analyze the specificity of the helminths recovered. The coot was a main host of 14 species of helminths, 12 of which are specific to the Rallidae. In addition, the coot is an auxiliary host of four species, an accidental host of six species and an inhibitory host of twelve species, including the most abundant form. Most of the species not specific to the Rallidae are found in a wide variety of water birds. The helminths of these ecological associates of the coot appear to affect the coot more than the coot helminths affect these birds.

Neither the sex nor the condition of the coots (as measured by fat or emaciation indices) appeared to affect their helminth fauna. Age of the coots, however, did affect their helminth fauna. Two species which occurred regularly in adults did not appear in the immatures. In addition, five species were found only in adults and six only in immatures, but these were all accidental or inhibited parasites which occurred rarely. Two of the species found in both age groups were maintained primarily by infections in adults and four others primarily by infections in immatures. The total intensity of

infection with all helminths was greater in the immatures; in almost all species the intensity of infection in the immatures was equal to or greater than that in the adults regardless of extensity. These factors suggest a lower resistance to infection in the immatures.

Immature coots acquired their helminths slowly; no helminths were recovered from coots under two weeks of age and it took approximately two months to acquire most of the helminth species. The correlation between order of acquisition and abundance or specificity reported by other authors were not found in this study.

Differences in the extensities and intensities of infection of major helminth species were found between the collections of 1963 and 1964. These differences were due to changes in the environment and consequent changes in the habitats sampled.

Seasonal fluctuations in the extensity of infection of the major helminths were grouped into five patterns. One species had a spring peak, six species had peaks in both spring and fall, six had summer peaks, one had a fall peak and two others showed irregular fluctuations. These patterns were produced by an interaction of various factors, including the life span of the parasite, changes in the abundance of intermediate host and/or infective stages of the helminths, and changes in feeding behavior of the coots. Decreases in the extensity and intensity of infection in June which were found in helminths or groups of helminths were correlated with the hatching phase of the coot reproductive cycle.

The two species limited to adult coots appear to be southern

species. The other coot helminths all appear to be "ubiquists".

Although the three habitats sampled all belonged to Gallimore's (1964) category of sloughs, differences in composition and abundance of the various helminth species were found. These differences were related to the size and uniformity of the habitat.

An analysis of stomach contents of the coots collected in this study indicated that they were omnivorous and fed mainly on plant material but also on a wide variety of animals. This diversity of food was correlated with the diversity of helminths recovered. Some of the variation in helminth infections with age, season and habitat differences appear to be correlated with differences in food habits.

The known intermediate hosts of the common helminths were not adequately revealed by the food analysis. Only the forms resistant to complete digestion were found. Other food items could only be revealed by the extent of the helminths they carried.

Since almost all coot helminths are biohelminths, the food habits of the coot determine its exposure to them. However, the biology of the parasites, and the physiological conditions of the host modify this initial exposure into the actual infection.

Minor pathological conditions produced by helminths were common. None of these were debilitating. Two cases of non-helminthic pathology appeared to be more serious.

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APPENDICES

Appendix I. Seasonal distribution of major helminth species.

Parasite	No. of Birds		*Cotylurus hebraicus*					
Host age	Adult	Immature	Adult			Immature		
			Ext.	Intensity		Ext.	Intensity	
Date				Mean	Range		Mean	Range
Apr. 16-30	10		10	6.0	6			
May 1-15	34		3	7.0	7			
May 16-31	33		3	1.0	1			
June 1-15	27							
June 16-30	30	4						
July 1-15	22	17						
July 16-31	21	17						
Aug. 1-15	16	22				5	55.0	55
Aug. 16-31	19	19	5	1	1	11	4.5	3-6
Sept. 1-15	14	22				9	8.5	1-16
Sept. 16-30	4	17				6	26.0	26
Oct. 1-15		10				10	10.0	10
Oct. 16-31		8						
Nov. 1-15		5						
Total	230	141	2	3.8	1-7	5	16.7	1-55

Appendix I (continued)

Parasite	*Cyclocoelum mutabile*						*Cyclocoelum oculeum*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	10	2.0	2				50	1.2	1-2			
May 1-15	18	2.2	1-5				32	2.2	1-6			
May 16-31	33	5.7	1-32				39	2.2	1-4			
June 1-15	22	1.3	1-2				15	1.5	1-2			
June 16-30	23	3.1	1-9				20	1.5	1-3			
July 1-15							5	1.0	1			
July 16-31	19	3.7	1-9				14	2.3	1-3			
Aug. 1-15												
Aug. 16-31				21	3.8	1-7						
Sept. 1-15				27	2.5	1-5	14	1.5	1-2	9	1.5	1-2
Sept. 16-30				29	7.2	2-15	25	4.0	4	24	2.0	1-3
Oct. 1-15				20	10.5	1-20				50	2.6	1-5
Oct. 16-31				38	10.7	1-28				50	2.3	1-3
Nov. 1-15				20	10.0	10				20	5.0	5
Total	15	3.5	1-32	14	6.2	1-28	20	1.9	1-6	11	2.3	1-5

Appendix I (continued)

Parasite	*Neoleuchloridium problematicum*						*Echinostoma attenuatum*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30							40	13.5	3-40			
May 1-15	3	7.0	7				9	3.7	2-5			
May 16-31	9	9.0	3-20				36	12.3	1-42			
June 1-15	19	23.8	1-91				19	6.0	1-16			
June 16-30	13	6.3	4-11				20	37.0	1-200			
July 1-15	13	13.6	2-29	29	75.0	13-270	13	2.7	1-4	53	39.7	1-180
July 16-31	24	5.2	1-14	52	50.8	4-190	29	3.5	1-14	53	9.1	2-30
Aug. 1-15	6	2	2	55	14.8	2-47	25	3.8	2-8	55	21.0	6-40
Aug. 16-31	11	12	7-17	21	9.5	1-22	26	4.2	1-13	47	5.0	1-12
Sept. 1-15	36	3.4	1-6	18	12.8	7-24	21	4.0	1-10	45	9.0	1-27
Sept. 16-30				11	5	3-7	25	1.0	1	35	8.3	1-9
Oct. 1-15										30	21.6	2-50
Oct. 16-31				12	1	1				25	1.5	1-2
Nov. 1-15												
Total	13	9.9	1-91	29	29.8	1-270	23	10.2	1-200	43	15.7	1-180

Appendix I (continued)

Parasite	*Echinostoma chloropodis*						*Notocotylus pacifera*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intenstiy	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30							20	2.0	2			
May 1-15							15	10.2	5-21			
May 16-31	9	11.6	1-32				12	1.0	1			
June 1-15	15	6.3	2-18				30	3.1	1-9			
June 16-30	13	39.2	2-150				13	1.5	1-2			
July 1-15	5	1.0	1				23	5.8	1-15	53	14.0	1-50
July 16-31							52	2.7	1-7	59	10.4	1-50
Aug. 1-15							38	6.2	1-17	55	14.3	1-60
Aug. 16-31							37	4.1	1-14	63	9.2	2-24
Sept. 1-15							50	6.0	1-13	55	8.3	1-22
Sept. 16-30				6	1.0	1	50	2.0	2	47	5.8	1-15
Oct. 1-15										50	6.4	1-17
Oct. 16-31										38	4.3	2-7
Nov. 1-15										60	6.8	1-16
Total	5	18.2	1-150	1	1.0	1	27	4.4	1-21	52	9.8	1-60

Appendix I (continued)

Parasite	*Tanasia atra*						*Ochipedum tracheicola**					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	40	1.5	1-2				11	1.0	1			
May 1-15	26	4.3	1-8				42	4.8	1-9			
May 16-31	36	4.5	1-15				47	2.8	1-11			
June 1-15	30	6.4	3-10				28	1.2	1-2			
June 16-30	43	7.5	1-24									
July 1-15												
July 16-31	10	1.0	1				10	1.0	1			
Aug. 1-15	19	6.0	1-14	5	3.0	3				20	1.0	1
Aug. 16-31	16	8.3	6-10	21	6.3	2-12						
Sept. 1-15	50	6.6	2-17	14	17.7	3-45				7	2.0	2
Sept. 16-30	25	3.0	3	29	5.4	1-12						
Oct. 1-15				50	7.0	1-15				83	3.4	2-5
Oct. 16-31				63	18.6	11-30				50	4.0	2-7
Nov. 1-15										40	8.0	8
Total	27	5.5	1-24	16	10.3	1-45	18	3.0	1-11	20	4.0	1-8

* 1964 data only

Appendix I (continued)

Parasite	*Diorchis americana*						*Diorchis ransomi*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	10	4.0	4									
May 1-15	6	28.0	3-53				3	3.0	3			
May 16-31	3	2.0	2									
June 1-15	7	6.5	2-11				7	8.0	2-14			
June 16-30												
July 1-15										35	11.6	1-52
July 16-31	14	2.3	1-4	6	16.0	16				12	10.5	6-15
Aug. 1-15	31	25.8	1-100	50	6.6	1-25				32	10.3	3-20
Aug. 16-31	11	4.0	1-7	26	3.0	2-10	5	4.0	4	50	31.2	1-150
Sept. 1-15				13	19.7	7-34						
Sept. 16-30				12	1.5	1-2				12	7.0	6-8
Oct. 1-15												
Oct. 16-31												
Nov. 1-15												
Total	7	13.7	1-100	16	7.5	1-34	2	5.8	2-14	19	17.2	1-150

Appendix I (continued

Parasite	*Lateriporus* sp. B						*Cestode* sp. A					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	30	6.0	1-9									
May 1-15	20	8.9	1-51				15	2.6	1-5			
May 16-31	15	11.0	4-25									
June 1-15	25	8.6	1-43				4	1.0	1			
June 16-30	10	4.0	1-8				3	18.0	18			
July 1-15	12	32.0	7-64				5	2.0	2			
July 16-31				5	1.0	1				6	2.0	2
Aug. 1-15				4	1.0	1				5	1.0	1
Aug. 16-31												
Sept. 1-15	14	3.0	1-5	9	5.0	1-9				5	1.0	1
Sept. 16-30				29	15.0	3-50				6	1.0	1
Oct. 1-15				33	3.7	1-7						
Oct. 16-31				28	6.0	1-11						
Nov. 1-15				20	10.0	10				10	10.0	10
Total	13	10.3	1-64	12	9.9	1-50	3	4.3	1-18	4	3.0	1-10

Appendix I (continued)

Parasite	Capillaria fulicae*						Amidostomum fulicae					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30							100	5.5	1-15			
May 1-15							93	10.3	1-33			
May 16-31							100	7.5	1-21			
June 1-15	11	22.0	22-24				85	8.6	1-30			
June 16-30	28	1.8	1-4				87	5.7	1-14			
July 1-15	36	1.8	1-2				77	3.8	1-7			
July 16-31	21	1.3	1-2				43	4.7	1-19			
Aug. 1-15							38	3.3	1-10	9	3.5	2-5
Aug. 16-31							32	3.0	1-7	32	3.0	1-6
Sept. 1-15							43	2.7	1-5	55	4.2	1-9
Sept. 16-30							25	2.0	2	24	2.3	1-3
Oct. 1-15										50	4.4	2-9
Oct. 16-31										50	22.0	3-59
Nov. 1-15										80	12.0	1-32
Total	10	4.3	1-24				71	6.5	1-33	26	6.5	1-59

* 1964 data only

Appendix I (continued)

Parasite	Tropisurus sp.						*Spirofilaria fulicae-atra**					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	50	5.0	1-12									
May 1-15	21	2.0	1-4				37	2.4	1-7			
May 16-31	9	2.0	1-4				53	3.5	1-11			
June 1-15	30	2.0	1-5				11	4.0	4			
June 16-30	47	3.5	1-19				56	1.7	1-4			
July 1-15	23	4.0	1-12				45	2.4	1-4			
July 16-31	24	2.2	1-3				40	2.0	1-3			
Aug. 1-15	6	1.0	1	9	1.0	1	43	3.7	1-7			
Aug. 16-31	11	2.5	1-4				45	5.2	3-9			
Sept. 1-15	28	1.8	1-3	18	1.0	1	83	2.4	1-3			
Sept. 16-30	25	2.0	2	24	2.3	1-3	25	5.0	5			
Oct. 1-15				20	2.5	1-4						
Oct. 16-31												
Nov. 1-15				20	18.0	18						
Total	24	2.8	1-19	9	3.6	1-18	41	2.8	1-11			

* 1964 data only

Appendix I (continued)

Parasite	*Polymorphus trochus*						*Polymorphus paradoxus*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	70	8.7	2-24				20	5.5	1-10			
May 1-15	56	12.9	1-31				35	4.8	1-18			
May 16-31	64	8.6	1-47				21	2.8	1-6			
June 1-15	52	13.2	1-60				19	1.6	1-2			
June 16-30	60	5.1	1-12				3	3.0	3			
July 1-15	89	12.7	1-36	6	12.0	12	22	3.3	1-6			
July 16-31	81	11.5	2-38	88	21.4	4-45	19	2.0	1-3	24	2.0	1-4
Aug. 1-15	94	12.1	1-34	46	16.8	3-53	6	3.0	3	9	1.0	1
Aug. 16-31	74	10.3	1-43	68	11.1	2-30	32	2.5	1-6			
Sept. 1-15	79	5.4	1-23	86	21.2	2-50	36	2.2	1-4	45	2.7	1-9
Sept. 16-30	75	17.0	3-30	82	17.7	2-32	25	1.0	1	12	1.0	1
Oct. 1-15				100	29.4	2-140				20	3.0	2-4
Oct. 16-31				100	17.4	1-39				50	1.3	1-2
Nov. 1-15				80	31.2	1-66						
Total	67	10.3	1-60	67	19.7	1-140	21	3.2	1-18	18	1.9	1-9

Appendix I (continued)

Parasite	*Polymorphus* spp.						*Coryonosoma ?constrictum*					
Host Age	Adult			Immature			Adult			Immature		
	Ext.	Intensity		Ext.	Intensity		Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range		Mean	Range		Mean	Range
Apr. 16-30	80	38.4	7-65									
May 1-15	97	50.4	1-180				12	2.5	1-5			
May 16-31	79	68.2	1-500				3	1.0	1			
June 1-15	67	33.8	1-110									
June 16-30	60	29.7	1-260									
July 1-15	68	75.5	2-300	12	3.0	1-5						
July 16-31	48	22.7	1-160	82	42.8	1-180				12	3.0	1-5
Aug. 1-15	62	17.7	1-160	27	18.0	1-82						
Aug. 16-31	42	8.4	3-18	42	3.2	1-11				11	4.5	1-8
Sept. 1-15	93	37.8	2-180	77	56.0	1-500						
Sept. 16-30	75	88.0	19-180	88	100.2	1-800						
Oct. 1-15				80	57.8	14-145						
Oct. 16-31				88	42.1	1-90				13	1.0	1
Nov. 1-15				100	48.0	15-86						
Total	70	44.8	1-500	60	50.0	1-800	2	2.2	1-5	4	3.2	1-8

Appendix I (continued)

Parasite	*Thermyzon rude*					
Host Age	Adult			Immature		
	Ext.	Intensity		Ext.	Intensity	
Date		Mean	Range		Mean	Range
Apr. 16-30	10	1.0	1			
May 1-15	9	1.3	1-2			
May 16-31	9	1.7	1-2			
June 1-15	4	1.0	1			
June 16-30	13	1.8	1-3			
July 1-15	5	2.0	2			
July 16-31	14	1.6	1-2	12	1.5	1-2
Aug. 1-15	31	1.2	1-2	36	1.8	1-4
Aug. 16-31	21	2.5	1-3	52	3.0	1-5
Sept. 1-15				9	1.0	1
Sept. 16-30				35	1.2	1-2
Oct. 1-15				10	1.0	1
Oct. 16-31						
Nov. 1-15						
Total	12	1.3	1-3	21	1.7	1-5

Appendix II. Comparison of major helminth species from sloughs, Cooking Lake and Hastings Lake.

Parasite		No. of Birds			*Cyclocoelum mutabile*					
Habitat		Sloughs	Cooking	Hastings	Sloughs		Cooking		Hastings	
Date					Ext.	Int. Range	Ext.	Int. Range	Ext.	Int. Range
Adult	May 16-31	14	9	10	21	5.1 4-7	44	3.0 1-8	40	8.8 1-32
	June 1-15	7	10	10	14	2.0 2	40	1.3 1-2	10	1.0 1
	June 16-30	12	8	10	8	9.0 9	50	2.3 1-5	20	2.0 2
	July 1-15	5	10	7						
	July 16-31	2	11	8	50	1.0 1	9	2.0 2	25	6.0 3-9
	Aug. 1-15	2	9	5						
	Aug. 16-31	4	5	10						
Immature	July 1-15	15	1	1						
	July 16-31	3	10	4						
	Aug. 1-15	9	10	3						
	Aug. 16-31	2	8	9			25	6.0 5-7	22	1.5 1-2

Appendix II (continued)

Parasite		*Cyclocoelum oculeum*						*Neoleucochloridium problematicum*					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hastings	
Date		Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range
Adult	May 16-31	29	2.7 / 1-4	44	2.3 / 1-4	50	1.6 / 1-2	14	11.5 / 3-20	11	4.0 / 4		
	June 1-15			20	1.5 / 1-2	20	1.5 / 1-2	14	19.0 / 19.0	30	33.0 / 1-91	10	1.0 / 1
	June 16-30	17	1.0 / 1	13	1.0 / 1	30	2.0 / 1-3	17	4.5 / 4.5	20	8.0 / 5-11		
	July 1-15					14	1.0 / 1			30	13.3 / 2-29		
	July 16-31					38	2.3 / 1-3			45	5.2 / 1-14		
	Aug. 1-15											20	2.0 / 0
	Aug. 16-31							25	17.0 / 17			10	7.0 / 7
Immature	July 1-15							20	30.6 / 18-43	100	270 / 270	100	13.0 / 13
	July 16-31							67	27.0 / 22-32	90	56.1 / 4-190		
	Aug. 1-15							44	14.3 / 10-18	80	15.0 / 2-47		
	Aug. 16-31							50	13.0 / 13	12	22.0 / 22	22	1.5 / 1-2

Appendix II (continued)

Parasite		Echinostoma attenuatum						Notocotylus pacifera					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hastings	
	Date	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range
Adult	May 16-31	57	13.1/2-42	22	15.5/1-30	20	5.5/1-10	21	1.0/1	11	1.0/1		
	June 1-15	43	8.0/1-16	20	3.0/1-5			14	2.0/2	40	2.5/1-4	30	4.8/1-9
	June 16-30	33	51.2/1-200	25	1.5/1-2			8	1.0/1	25	2.0/2	10	1.0/1
	July 1-15	20	3.0/3	10	4.0/4	14	1.0/1			30	8.0/3-15	29	2.5/1-4
	July 16-31	100	7.5/1-14	18	4.5/1-8	38	1.6/1-3	50	2.0/2	45	1.6/1-4	63	4.0/2-7
	Aug. 1-15	100	2.5/2.3	22	5/2-8			50	2.0/2	56	7.0/1-17		
	Aug. 16-31	25	1.0/1	20	13/13	30	2.3/1-3			80	6.0/1-14	30	2.5/1-3
Immature	July 1-15	53	44.5/1-180	100	1.0/1			53	15.5/1-50	100	2.0/2		
	July 16-31	33	19.0/19	40	5.0/2-8	100	10.8/4-30	33	11.0/11	70	12.0/2-50	50	4.5/1-8
	Aug. 1-15	89	15.3/6-40	10	90.0/90	100	6.7/6.7	56	23.9/3-60	60	8.3/1-23	33	2.0/2
	Aug. 16-31	50	9.0/9	75	4.7/1-12	22	4/1-7			75	11.7/4-24	67	6.7/3-14

Appendix II (continued)

Parasite		*Tanasia atra*						*Diorchis americana*					
Habitat		Sloughs		Cooking		Hasting		Sloughs		Cooking		Hastings	
	Date	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range
Adult	May 16-31	43	2.7 / 1-5	44	7.5 / 3-15	20	4.0 / 3-5					10	2.0 / 2
	June 1-15	28	4.0 / 3-5	40	8.0 / 7-10	20	5.5 / 4-7	14	2.0 / 2	10	11.0 / 11		
	June 16-30	50	6.0 / 1-24	38	10.3 / 1-17	40	7.8 / 2-20						
	July 1-15												
	July 16-31			9	1.0 / 1	13	1.0 / 1	50	2.0 / 2			25	2.5 / 1-4
	Aug. 1-15			33	6.0 / 1-14					56	25.8 / 1-100		
	Aug. 16-31					30	8.3 / 6-10	50	10.0 / 10	20	7.0 / 7	10	1.0 / 1
Immature	July 1-15												
	July 16-31									10	16.0 / 16		
	Aug. 1-15	11	3.0 / 3					78	7.3 / 1-25	30	5.7 / 2-12	33	5.0 / 5
	Aug. 16-31			38	5.7 / 2-12	11	8.0 / 8			13	4.0 / 4	25	2.5 / 2-3

Appendix II (continued)

Parasite		*Diorchis ransomi*						*Lateriporus* sp. B					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hasting	
	Date	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range
Adult	May 16-31									55	11.0/4-25		
	June 1-15	14	2.0/2	10	14.0/14					30	15.0/1-45	40	3.8/1-7
	June 16-30									13	8.0/8	20	2.0/1-3
	July 1-15							20	64.0/64	10	7.0/7	14	25.0/25
	July 16-31												
	Aug. 1-15												
	Aug. 16-31					10	4.0/4						
Immature	July 1-15	6	40.0/1-52										
	July 16-31	33	15.0/15	10	6.0/6					10	1.0/1		
	Aug. 1-15	44	16.3/9-20	30	4.3/3-6			11	1.0/1				
	Aug. 16-31	50	150/150	63	20.2/1-56	38	10.0/2-25						

Appendix II (continued)

Parasite		Amidostomum fulicae						Tropisurus sp.					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hastings	
	Date	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range	Ext.	Int./Range
Adult	May 16-31	100	2.0/2	100	9.8/1-21	100	5.9/2-11	21	2.0/1-4				
	June 1-15	71	6.4/3-15	90	10.6/1-30	90	7.9/3-12	57	2.0/1-5	10	3.0/3	30	1.7/1-3
	June 16-30	83	5.8/2-14	88	6.9/3-12	90	4.8/1-12	42	5.2/1-19	50	1.3/1-2	50	3.6/1-9
	July 1-15	80	3.3/1-6	60	3.8/1-6	100	4.0/1-7			30	2.3/1-4	29	6.5/1-12
	July 16-31	50	1.0/1	55	6.0/1-19	25	2.5/2-3	50	2.0/2	27	1.7/1-2	13	3.0/3
	Aug. 1-15			44	3.5/1-10	40	2.5/2-3			11	1.0/1		
	Aug. 16-31	25	7.0/7	40	1.0/1	30	3.0/1-7					20	2.5/1-4
Immature	July 1-15												
	July 16-31												
	Aug. 1-15	11	2.0/2			33	5.0/5	11	1.0/1			33	1.0/1
	Aug. 16-31			38	3.0/1-6	33	3.0/1-5						

Appendix II (continued)

Parasite		*Polymorphus trochus*						*Polymorphus paradoxus*					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hastings	
	Date	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range
Adult	May 16-31	50	3.3 / 1-14	78	9.0 / 1-14	70	13.6 / 1-47	29	4.0 / 3-6	11	1.0 / 1	20	1.5 / 1-2
	June 1-15			90	12.0 / 1-31	50	25.4 / 2-60			30	1.3 / 1-2	20	2.0 / 2
	June 16-30	25	4.8 / 1-9	88	4.1 / 1-6	80	6.1 / 1-12					10	3.0 / 3
	July 1-15	20	3.0 / 3	90	13.9 / 1-36	100	10.7 / 1-25			20	3.5 / 1-6	29	3.0 / 3
	July 16-31	50	2.0 / 2	100	13.9 / 4-38	63	8.2 / 4-18			44	2.0 / 1-3		
	Aug. 1-15	100	17.5 / 1-34	100	11.4 / 1-32	80	10.8 / 1-17					20	3.0 / 3
	Aug. 16-31	50	1.5 / 1-2	80	7.3 / 4-13	80	14.0 / 3-43			60	4.0 / 2-6	20	1.0 / 1
Immature	July 1-15			100	12.0 / 12								
	July 16-31	33	16.0 / 16	100	23.6 / 4-61	100	17.3 / 10-33			40	2.0 / 1-4		
	Aug. 1-15			100	16.8 / 4-53					10	1.0 / 1	33	1.0 / 1
	Aug. 16-31	50	10.0 / 10	88	12.7 / 2-30	56	9.0 / 2-17	50	1.0 / 1				

Appendix II (continued)

Parasite		Polymorphus spp.						Theromyzon rude					
Habitat		Sloughs		Cooking		Hastings		Sloughs		Cooking		Hastings	
Date		Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range	Ext.	Int. / Range
Adult	May 16-31	50	17.6 / 1-63	100	137 / 2-240	100	41.3 / 9-180	14	1.5 / 1-2	11	2.0 / 2		
	June 1-15			80	26.6 / 1-90	100	39.5 / 1-112	17	1.0 / 1				
	June 16-30	3	8.3 / 2-18	88	55.0 / 1-260	80	15.5 / 1-30	17	1.0 / 1	13	2.0 / 2	10	3.0 / 3
	July 1-15	20	300 / 300	70	43.7 / 2-170	100	75.1 / 8-270			10	2.0 / 2		
	July 16-31			77	30.0 / 2-160	38	5.7 / 1-11			18	2.0 / 2	13	1.0 / 1
	Aug. 1-15			56	1.6 / 1-2	80	42.3 / 1-160			33	1.0 / 1	40	1.5 / 1-2
	Aug. 16-31	75	11.7 / 8-18	20	6.0 / 6	40	6.5 / 3-9	25	1.0 / 1	40	2.0 / 2	10	1.0 / 1
Immature	July 1-15	7	1.0 / 1			100	5.0 / 5						
	July 16-31	33	1.0 / 1	90	64.6 / 1-180	100	4.3 / 1-8	33	2.0 / 2	10	1.0 / 1		
	Aug. 1-15			60	11.3 / 1-37	100	31.3 / 3-82	22	1.0 / 1	40	1.3 / 1-2	67	3.5 / 3-4
	Aug. 16-31			50	3.5 / 1-11	44	2.8 / 1-4			38	2.3 / 1-5	78	2.3 / 1-4